THURSDAY DECEMBER 19, 1895.

THE ORIGIN OF PLANT STRUCTURES.

The Origin of Plant Structures by Self-adaptation to the Environment. By the Rev. G. Henslow, M.A., F.L.S., &c. International Scientific Series. Pp. xii + 256. (London: Kegan Paul, 1895.)

THE present work may be regarded as the second part of the "Origin of Floral Structures," published by the same author in 1888. In that volume Prof. Henslow propounded his Neo-Lamarckian view, that all differences of colour, shape, and size of floral organs have been directly caused by the influences surrounding the plant. The visits of insects, with their constant thrusts and probings, have produced, as a direct result, all the variety of the phanerogam flower.

In the present volume, the same proposition is extended to the vegetative organs of plants, of which the efficient cause of diversity, whether of external or internal morphology, is to be sought in changes in the conditions of life. In this way the author makes studies of the following special cases:—Desert plants, Arctic and Alpine plants, maritime and saline plants, phanerogamous aquatics, subterranean structures, climbing stems and leaves. From a careful analysis of the biological peculiarities of these forms, Prof. Henslow claims to draw strong support for his views.

The Darwinian hypothesis assumes, in the offspring, constant minute variations in all directions from the parent type: those variations that are of service to the plant in its struggle for existence, are perpetuated and increased by natural selection and heredity. Prof. Henslow denies the existence of natural selection altogether: variations in nature, according to him, are never indefinite, but always definite, and, being induced by the change of environment, and the responsive action of protoplasm, they are always in the direction of adapting a plant to its surroundings.

The test of a theory lies in the wideness of its application; and herein exists the great beauty of Darwin's hypothesis. After all these years of severest criticism, no definite proofs have been urged against it; and the best that Prof. Henslow can do is to offer a substitute which, to his mind, furnishes an easier solution to the difficulties of certain selected cases.

Whatever may be the opinion of others, the author himself is sure of his ground. The introduction opens with these words: "Natural Selection plays no part in the Origin of Species." This dictum is not likely to be accepted by the general scientific world without very strong support. The imputation of narrowness of field in Darwin's observations is hardly in good taste, while such headings as "Darwin's Fundamental Error" predispose the mind to a critical attitude.

It is usually agreed that, from the nature of the case, a definite proof of the action of natural selection is difficult, if not impossible, in the present state of our knowledge. This the author of the present volume concedes, and at the same time puts forth arguments against the probability of such proofs being forthcoming. With considerable skill, if with rather superfluous detail, he discusses the manner in which the environment impresses itself upon the anatomy of plants. Of the *inheritance* of such acquired characters there is no proof at all. We are offered instead the "argument of coincidences" and the "cumulative evidence of probabilities, which amounts to a moral conviction." Clearly, before rejecting a well-established and widely applicable hypothesis, something more tangible is required.

In each section of the present volume, Prof. Henslow presents the reader with an interesting picture of the biology of a group of plants. The descriptions would, we think, be clearer if the writer had condensed his quotations somewhat. As it is, the interpolation in the text of long passages—frequently in French—mars the simplicity.

We emphasise this point because of the character of the author's reasoning. He is an exceedingly plausible and persevering casuist; and it is, on that account, all the more desirable that the reader should retain a clear impression of the course of the argument.

To take a specimen of the author's method. In speaking of the frequent hairiness of desert plants, as contrasted with those more favourably situated, Prof. Henslow quotes Mer, to the effect that "*cæteris paribus* hairs are the result of localised extra nourishment." This, he points out, was long ago suggested by Aug. Pyr. de Candolle as the cause of the hairiness of the barren inflorescence of *Rhus Cotinus*, where the nutrition, which would normally be applied to the formation of flowers and seeds, finds a new outlet. So with the hairy filaments of *Verbascum* and other flowers where some of the anthers are barren or suppressed; also, as Masters has pointed out, the hairy outgrowths in many galls.

The "localised extra nourishment" of desert plants the author accounts for in the following manner. There is a characteristic diminution in the size of the leaves in desert plants, due principally to a decrease in the parenchymatous tissues; hence, it is argued, there is an arrested food supply which, "by a compensating process," is used up in the formation of hairs.

To take another instance: the rapid maturing and seeding of plants, in regions of short summer, is traced to the changes which take place in the reserve materials during the low temperatures of the long winter preceding, just as frosted potatoes shoot out quickly in the spring.

We are not sure that, in these attempts to define the exact mode of "the responsive action of protoplasm," the author does not deprive it of more of its independent and unexplained reactions than is justified by our present knowledge.

In a word, each argument, although composed of a chain of neat and plausible propositions, lacks coherence and, somehow, fails to carry conviction. In each change of environment, the protoplasm is, so to speak, induced, by a kind of internal conjuring, to present the very modification of structure which will be of service to the plant under the altered conditions.

It has been pointed out that only isolated cases have been dealt with in this volume; but, for the hypothesis to be acceptable, it must be widely applicable. We should like to learn how the beautifully fashioned hooks

of the seeds of *Martynia* have been formed, or the delicate tracery of the pappus of *Tragopogon*, the insectivorous glands of *Drosera*, the roots of *Acanthorrhiza* which grow upwards and become a thorny hedge around the young plant, or the profusion of thorns upon the palms of moist tropical forests. Although fraught with difficulties, the Darwinian theory embraces all such cases; while that defended by the author requires a new line of argument in each separate instance.

Prof. Henslow is rich in expedients, and is a fearless theoriser. He regards the opposite or decussate arrangement of leaves as the primitive, because of the position of the cotyledons; the sheathing base of *Monocotyledons* and *Umbellifers* is a mark of degeneracy; the heterophylly of *Juniperus* is caused by a variation in the amount of nutriment at the plant's disposal. He suggests that the enlarged watery, subterranean parts of desert plants may be due to the blistering action of the hot sand, and that the thickened cuticle of plants in dry climates may be formed or aided by a deoxidation of chlorophyll by excessive light. Lastly, he explains the fact, observed by Volkens, that the stomata of desert plants are frequently closed in the day and open at night, by a reversal of the ordinary reactions of the guard cells to turgescence. "Perhaps the arrested moisture, due to the check to transpiration, may cause turgescence by day, which closes the slit, while its cessation at night brings about a relaxation."

We confess that Prof. Henslow's views on geotropism are puzzling and disappointing. He denies the existence of negative geotropism; and bases his argument, curiously enough, upon Knight's well-known wheel experiment. Here he discovers a *centripetal pulling* force which causes the stem apex to grow towards the centre of the rotating wheel, and at the same time a *centrifugal pulling* force which causes the root to grow outwards. "Each end of the plant is therefore subjected to what might be called an accelerating 'pulling' force." A moment's consideration will show that there is no such *centripetal pulling* force acting upon the free stem-apex. Prof. Henslow seems to lose sight of the fact that the action of gravity upon parts of plants is directive rather than purely mechanical.

Further, it is not clear why gravity ceases to act upon the apex of *Ranunculus heterophyllus* because it is immersed in water (p. 201)!

There are many points which will exercise the morphologist. Why are the first leaves of water plants regarded as phyllodes? We hardly agree with Prof. Henslow's ideas on the interchangeability of stems and roots in nature, although each may arise from the other endogenously.

Then again, it is difficult to follow the author's description of the vascular system of water plants on pages 145–7. We gather that he regards "spirals" as the only true "tracheæ"; and "vessels" appear to have quite a different meaning. The following is far from clear: "In aquatics the punctated vessels may closely simulate punctated fibres, the chief differences being in the lessened diameter of the latter, and the more or less oblique position of the septa. Then these pass into thin-walled fibres of the same shape, and finally become 'fibrous cells,' when they may contain starch."

We have read the volume with great pleasure, both because of the mass of interesting details of plant biology, and the ingenious piecing together of evidence; nevertheless, we do not think that Prof. Henslow's attempts to reconstitute the theory of evolution are altogether successful. C. A. BARBER.

SOLUTION AND ELECTROLYSIS.

Solution and Electrolysis. By W. C. Dampier Whetham, M.A. (Cambridge: The University Press, 1895.)

UP till the beginning of the present year the English reader had practically only two text-books to guide him in getting some idea of the scope and importance of the Newer Theory of solutions. These were "Solutions," a translation of certain parts of Ostwald's Lehrbuch, and "Outlines of General Chemistry," by the same author. The former gave but an imperfect account of the subject, as it excluded the electrical properties of solutions, and thus the mass of material which groups itself around the hypothesis of electrolytic dissociation; while the latter, although giving a general survey of the theory, dealt with it in but a superficial manner. To these was added, early in the present year, Nernst's "Theoretical Chemistry," and in this book is to be found the best description in English of the present condition of the theory; for although the description is by no means rich in records of actual observations, yet, on account of the neat methods used in dealing with the theory of individual questions, and the comprehensive mode of attacking the entire subject, it is worthy of the attention of all students of physical chemistry.

The book under notice gives a much more detailed survey of the theory as a whole than that found in Ostwald's "Outlines." The mode of treatment is, however, less thorough than that in Ostwald's "Solutions," and has little resemblance to the compact and orderly method used by Nernst.

In his preface the author states that a considerable part of the first six chapters is taken from Ostwald's Lehrbuch, and this is unmistakably evident on reading them through. They deal with solubility, the different kinds of solutions, diffusion and osmotic pressure, freezing-points, and vapour-pressures. The remaining five chapters have much greater claims to originality, and are devoted to the electrical properties of solutions—Faraday's laws, polarisation, the theory of the voltaic cell, the migration and velocity of the ions, electric conductivity and its correlation with other properties, and theories of electrolysis.

The student familiar with the elements of physics and chemistry will have little difficulty in following the information supplied. The author has, in particular, to be thanked for setting out at length the more important applications of thermodynamics to solutions, as these are often a source of worry to the beginner. Many indications are also given of attention to points which are often scantily treated, as in the case of the theory of diffusion, the meaning of osmotic pressure, the theory of the voltaic cell, &c. On the other hand, the treatment of solutions in gases, associated solutions, Beckmann's molecular weight apparatus, &c., is extremely superficial. There

are also certain points to which attention must be drawn, in view of future editions of the book.

When dealing with plasmolysis (p. 37), the author omits to state that the animal or vegetable cells used must contain living protoplasm, and the reader is led to infer that artificially-coloured, instead of naturally-coloured cells are employed for plasmolytic observations. Although certain stains are known which are not immediately fatal to living cells, there is no record of their use in plasmolytic experiments. It is also made to appear that red blood corpuscles contain a semi-permeable membrane, despite the conclusive observations of Hamburger to the contrary. In connection with this subject, it is misleading to state (p. 38) that De Vries "established the most important generalisation" that solutions of the same molecular concentration are isotonic, for inasmuch as by far the greater number of his solutions were electrolytic, his results clearly contradict this statement. On p. 34, the credit of preparing semi-permeable membranes is given to Pfeffer, whereas M. Traube first described their preparation and properties. As regards the more general treatment of the first section, it is noteworthy that although the solubility of mixed substances is to some extent discussed, no notice is taken of the work of Roozeboom, and Gibbs' phase-rules, which apply to all cases of heterogeneous equilibrium in solution, are not even mentioned.

In the section on electrolysis, some inkling might have been given of the wide field opened up for the verification of the ionic hypothesis by its application to the operations of analytical chemistry. Among smaller points, it may be noted that, on p. 128, potassium platinichloride should be sodium platinichloride, and in a somewhat vague paragraph, on p. 164, we read that the introduction of oxygen, sulphur, or a halogen, which raises the affinity of a weak acid, "has no effect on the affinity of these strong acids." Since the strong acids quoted by the author are hydrochloric, nitric, &c., the student may be pardoned if he is puzzled to understand how the introduction is to be brought about, or what acids would result if it were possible.

A novel feature in a book of this kind is an attempt made by the author to reconcile the Hydrate Theory with the Newer Theory of solutions. Of course it has all along been apparent that the latter does not preclude combination between solvent and dissolved substance. What the upholders of the newer theory assert, however, is that at the present time there is no definite evidence that, in general, such combination exists. An attempt to reconcile the two views should therefore involve a careful study of the experimental data in favour of combination. It is for this reason unfortunate that the author gives but a very brief statement of the results of the extensive work of Pickering in this field.

As an appendix to the book is given part of the list of the conductivity, migration, and fluidity data of solutions compiled by Fitzpatrick for the British Association Report of 1893. For the sake of chemical readers it is to be regretted that most of Ostwald's observations on the conductivity of organic substances have been omitted, since it is in the case of such substances that the close connection between the electrolytic properties of solutions and the chemical nature of the dissolved substances can be most conveniently traced. J. W. RODGER.

THE THEORY OF ALGEBRAIC FORMS.

An Introduction to the Algebra of Quantics. By E. B. Elliott, M.A., F.R.S. Pp. xiv. + 424. (Oxford: Clarendon Press, 1895.)

THE history of the theory of algebraic forms gives a striking example of the fact that the germ of a mathematical doctrine may remain dormant for a long period, and then suddenly develop in a most surprising way. The principles of the calculus of forms are to be found in the arithmetical works of Lagrange, Gauss, and Eisenstein; but the great expansion of the theory, with which we are now so familiar, practically dates from the publication of the papers of Boole, Cayley, and Sylvester, about fifty years ago.

It is well known that the theory of forms has advanced upon two distinct lines: one method being derived mainly from the differential equation of sources, supplemented by generating functions and the theory of equations; the other, from the symbolical representation of a quantic, invented by Aronhold, and applied with such power by Clebsch and Gordan. Until quite lately, the symbolical method might not unjustly claim to be superior in respect of organic unity, as it must still be admitted to be in compactness and geometrical suggestiveness; but the other method has now undergone a remarkable transformation at the hands of Hammond, MacMahon, Hilbert, and others, and has led to results of the highest interest and value, which the symbolical calculus could not easily or naturally supply.

With the exception of three pages, devoted principally to Cayley's hyperdeterminant notation, Prof. Elliott does not refer to the symbolical method. With his reasons for not using it we must reluctantly acquiesce. It is quite true, as he says, that a mere outline of the method would have been worse than useless; and by omitting it altogether, he has been enabled to give a very lucid and thorough account of the subject from one consistent point of view, without that excessive condensation which is so often a defect rather than a merit.

It is not necessary to say much of the earlier chapters, except that, like the rest of the book, they are very clear and pleasant to read; in particular, the proof that every covariant of a covariant is a covariant of the original form is easier to follow than that given by Salmon. It is when we come to chapters vi. and vii., which deal with seminvariants and their annihilators, that the influence of recent discoveries begins to be felt. Thus the notions of *excess* and *extent* are introduced, and the annihilators of invariants and covariants of systems of quantics are indicated.

Chapter viii. discusses generating functions, and is a very good introduction to this part of the subject. It does not profess to be exhaustive; and it is perhaps as well that the author has refrained from giving the detailed reduction of the generating functions for forms higher than the quartic. This would have taken up a good deal of space; and the full discussion for the lower forms, which is given, is quite enough to illustrate the general procedure. The results for the quintic are also stated, and references are given to the memoirs of Sylvester and Franklin, which ought to be easily understood by any one who has mastered this chapter.

Another very interesting chapter follows. This contains Hilbert's proof of Gordan's celebrated theorem, that the number of irreducible concomitants is finite. Compared with Gordan's original proof, this is simplicity itself; and it is unlikely that the demonstration can be essentially improved upon in this respect, although no doubt some simplification in detail may be effected.

Chapters x. and xi. are also well brought up to date. They deal with protomorphs and perpetuants, and the connection of seminvariants with non-unitary symmetric functions. It is needless to say that they are based principally on the researches of MacMahon and Hammond. The deduction of the annihilator of non-unitary symmetric functions of the quantic

$$b_0 x^p + \frac{b_1}{1!} x^{p-1} + \frac{b_2}{2!} x^{p-2} + \ . \ . \ . \ + \frac{b_p}{p!}$$

seems rather artificial, as it is made to depend upon the transformation

$$-\frac{\partial}{\partial s_1} = b_0 \frac{\partial}{\partial b_1} + 2b_1 \frac{\partial}{\partial b_2} + \ . \ . \ . \ p b_{p-1} \frac{\partial}{\partial b_p}$$

But this is a small matter, and the chapters are full of interest. One remarkable novelty is a differential operator which annihilates any rational integral function whatever of the coefficients of a finite quantic. Here is, indeed, a universal solvent. It should be added that the examples at the end of chapter xi. give a synopsis of Stroh's verification of MacMahon's brilliant conjecture that the generating function for perpetuants of degree i is

$$\frac{x^{2^{i-1}} - 1}{(1 - x^2)(1 - x^3) \ . \ . \ . \ (1 - x^i)} \ . \ . \ . \ (i > 2)$$

The remaining chapters (xii.–xvi.) treat of canonical forms, the binary quintic and sextic, systems of binary quantics, orthogonal invariants, and the ternary quadratic and cubic. The chapter on the quintic and sextic does not go into detail, but gives complete lists of the concomitants, and in particular the explicit forms (supplied by Mr. Hammond) for the quintic $(a, b, 0, 0, e, f)\,(x, y)^5$. The other chapters do not seem to call for special remark; suffice it to say that they maintain the high standard of those which precede them.

Prof. Elliott states in his preface that the book is an expansion of a course of lectures delivered annually for some years past at Oxford. To this fact, no doubt, may be attributed, in some measure, the lucidity and symmetry of the treatise. Another good feature, perhaps due to the same cause, is the occasional statement of what a theorem does *not* imply. To the well-informed reader this may seem superfluous, but it is by no means so in the case of a learner, who not infrequently reads into a theorem a degree of generality which it does not really contain.

To return to the symbolical method of Clebsch and Aronhold. Prof. Elliott admits that an English work on this calculus is a desideratum; will he not be persuaded to supply this want himself? It would be a great boon to have an English book something after the kind of the Clebsch-Lindemann "Geometrie," including, at least, the theory of plane quadratic and cubic curves, and of surfaces of the second order, with perhaps an introduction to the theory of cubic surfaces. This is, no doubt, a heavy task, but it is well worth attempting; the theory of forms is infinitely more interesting in its geometrical applications than as a mere branch of analysis, and it is here, above all, that the power of the symbolic method shows itself. Such a work would do much to avert the danger of divorcing the theory of forms from analytical geometry; a danger which is encouraged by the present regulations of the mathematical tripos, which place these cognate subjects in two different divisions. G. B. M.

SURFACE-COLOURS.

Die Oberflächen- oder Schiller-Farben. Von Dr. B. Walter. 1 vol., with 8 woodcuts and 1 plate. Pp. vi. + 122. (Braunschweig: F. Vieweg und Sohn, 1895.)

THIS work is primarily addressed to zoologists, mineralogists, and chemists, appealing in only a subordinate measure to physicists. On this account the mathematical developments most desirable for the physicist are reserved for appendices, while the text itself contains only such matter as is vital to the theory of surface-colours, together with very simple and well-established formulæ given without proof.

The importance to the first-named classes of an acquaintance with the physical basis of these colours immediately appears, says the author, from the facts that, on the one hand, to this class of colours belong the tints of many butterflies and birds, and also those of a series of crystals exhibiting the most gorgeous natural phenomena; and on the other hand, the technologist, if he desires artistically to imitate these colours, must naturally, first of all, obtain a true insight into their manner of production. Now, although this treatise contains no startling additions to our physical knowledge of surface-colours, it may yet be expected to render a most acceptable service to this branch of physics, since in many minds there still linger hazy, or even discordant, conceptions of these colours, and until now no work seems to have appeared devoting to the subject even any approach to an exhaustive treatment.

Of the experiments, which form the basis of the calculations and statements contained in this book, those which are new have been carried out by the author in the State Physical Laboratory at Hamburg.

The first chapter is a brief introduction to the subject of the work. The second and third chapters treat of the surface-colours of colourless materials and of metals respectively. In the fourth chapter, embracing about a third of the entire treatise, the author discusses the dichroic substances proper; solid fuchsine and diamond green, also solutions of these, and fluorescein solution being specially dealt with. This chapter is unusually rich in experimental results. It is pointed out that the body-colour and the surface-colour are only approximately complementary, and are not exactly so, as stated in Haidinger's law. We have also here the following important statement: "The coefficient of reflexion of a particular ray from a given substance depends not only upon the absorption coefficient of the substance for that ray, but also upon its refractive index for the ray in question, the relative importance of these two factors varying with circumstances, so that in the case of the feebly-absorbed rays of coloured substances the refractive index is prac-

tically the sole factor in determining the intensity of the reflected light."

In chapter v. the distinguishing characteristics which separate surface-colours from other classes of colours are noted. The following kinds of colours are treated: (1) body-colours; (2) the colours of turbid media; (3) the prismatic dispersion colours; (4) the spectral colours of the diffraction grating; and (5) the colours of thin plates. With reference to the latter, the author calls attention to the fact that if one changes the polarisation of the incident light used in producing the colours of thin plates, the result is simply a change in the *intensity* of the colours, no change in their *tint* being thereby caused; whereas with surface-colours proper, under the same circumstances, *both intensity and tint* are thereby changed. The body of the work concludes with a sixth chapter, dealing with the occurrence of surface-colours in the animal and mineral kingdoms.

E. H. B.

OUR BOOK SHELF.

Studies from the Biological Laboratories of the Owens College. Vols. i. (pp. 328), ii. (pp. 268), iii. (pp. 286), 1886, 1890, and 1895. (Manchester: Cornish.)

THERE is growing up among us a habit of collecting and publishing reprints of memoirs as "Studies" from this laboratory or from that; and a very excellent habit it appears to us to be. We have known for some years the "Studies from the Morphological Laboratory" of Cambridge; we have seen "Reports" from the Physiological Laboratory of University College, London; "Transactions" from Dundee, edited by Prof. D'Arcy Thompson, and quite recently we referred to the youngest of such publications, viz. the "Linacre Reports" of the zoological work at Oxford, edited by Prof. Ray Lankester.

All such collections serve the useful purpose of indicating the character and amount of work carried out at the various important teaching institutions of the kingdom, and of emphasising the fact that the best teaching work is performed by those engaged in research. It may be objected that the memoirs contained in such "Studies" can be found elsewhere. This is, in general, true; but, nevertheless, such collections help to associate more readily in our minds the workers with their masters and the institutions to which they are attached; and oftentimes it brings together, in a compact form, a series of contributions undertaken with some special object, by different workers it may be, or by one man.

The first volume of these "Studies" from Manchester was published in 1886, the second in 1890, the third during the present year; the last is under the editorship of Dr. Sydney Hickson, the two former by the late Professor. These volumes contain several valuable memoirs, some of which are already classical, such as Marshall's "Segmental Value of the Cranial Nerves," Beard's account of the Branchial Sense-organs, and Melland's contribution to the Histology of Striated Muscle; and to these will have to be added, no doubt, the researches of Marshall and Bles on the Development of the Vascular System, and of the Kidneys in the Frog, Robinson's observations on the Development of the Optic Nerve, Paterson's account of the Origin of the Nerve-plexus of the Limbs, and other embryological papers undertaken at the suggestion of the late Professor.

In addition to these developmental memoirs, those by Fowler on the anatomy of Corals, and by Garstang and by Gamble on the Fauna of the British Coasts, have a permanent value. In the last volume, Milnes Marshall's interesting "Address" at the British Association, dealing with "Recapitulation in Ontogeny," is reprinted.

The absence of botanical research in the later volumes is the more noticeable, as Prof. Marshall Ward contributed to the first volume. We hope that botanical research is not dead in Manchester.

Palæontology is represented by Dr. Hurst's account of *Archæopteryx*.

The quality and extent of ten years' work brought together in these three volumes, bear witness to the energy and influence of the late Beyer Professor; and we may echo Prof. Hickson's prefatory remark, that "his influence will long be felt in the writings of his pupils and successors."

Studies in Economics. By William Smart, M.A., LL.D. Pp. 341. (London: Macmillan and Co., 1895.)

DR. SMART is favourably known in the economic world by his admirable translations of the writings of the Austrian school; and in these "Studies" the characteristic doctrines of that school furnish no small part of the theoretic apparatus. The exclusive emphasis laid on that side of the theory of value, the elaboration of which is connected in this country chiefly with the name of Jevons—the side of demand, that is, with its controlling factor of marginal utility—is faithfully reproduced by Dr. Smart; and, like the teachers, whose disciple he frankly acknowledges himself to be, he is disposed to treat as "secondary" and "derivative" that influence of cost of production as governing supply, and, through supply, determining value, to which the older English economists, such as Ricardo and Mill, assigned predominant stress. He describes the Austrian theory as the "current" and "dominant" theory; and, while he sometimes accords a hesitating recognition to conceptions which seem to conflict with this exclusive emphasis, his attitude even here appears to be in reality one of doubtful acceptance rather than hearty concurrence. To the writer of this review the later, like the older emphasis, seems mistaken; and the comprehensive attitude of Prof. Marshall, who treats the two sides of supply and demand as mutually determining, appears to be more closely in accord with the facts; and in this impression he is strengthened by the difficulties encountered by Dr. Smart in some of these "Studies" from an unwillingness to allow to cost of production a coordinate influence with that of marginal utility in determining value. On Prof. Marshall's hypothesis the facts seem to fall naturally into their place, but by the Austrians and by Dr. Smart they appear to be forced artificially into a strained position. To this theoretic equipment Dr. Smart has added the valuable qualification of a first-hand acquaintance with the facts of business life; and the advantage of this intimate knowledge is evident in many parts of his book. It consists of three main sections, one devoted to studies in wages, the second to studies in currency, and the third to studies in consumption. Of these the first seems to us the most valuable; and the reason consists in the fact that Dr. Smart's business experience brings a strong admixture of practical sagacity to bear on such matters of concrete interest as a "living wage," the "sliding scale," and "women's wages." He owns in his preface to a proneness, not unnatural in a business man, to "lose himself in the fallacy of the particular instance"; and we are not sure that he has in the course of these "Studies" always avoided this fallacy. But he never fails to be interesting and suggestive, and he is, with rare exceptions, uniformly lucid; and these are qualities as admirable as they are rare in combination. The economic student and—in a more especial degree—the practical man, will find material for profitable reflection in the careful perusal of these interesting "Studies."

LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

Intensity and Quantity of Sunheat at Different Zones.

THE following figures may interest readers of NATURE. They give the relative summer and winter *intensities* of sunheat for every five degrees of latitude, *i.e.* the sunheat per square foot—and also the relative *total quantities* of heat received at the zones extending from 0°–5°, 5°–15°, &c.

Latitude	0°	5°	10°	15°	20°	25°	30°	35°	40°	45°
Summer Intensity	943	971	997	1016	1026	1030	1026	1016	997	973
Winter Intensity	961	915	866	808	752	694	634	569	498	423

Latitude	50°	55°	60°	65°	70°	75°	80°	85°	90°
Summer Intensity	947	909	868	840	821	806	793	780	766
Winter Intensity	345	269	197	135	79	40	18	5	0

Zone	0-5°	5-15°	15-25°	25-35°	35-45°	45-55°	55-65°	65-75°	75-85°
Summer Heat	478	987	964	886	764	612	434	286	84
Winter Heat	469	857	707	550	331	269	100	27	9

The figures are not guaranteed as accurate to the last place, but that place is included so that the totals may be fairly correct when we take the total sunheat over several zones. Thus we get the summer and winter sunheat up to latitude 30° in the ratio of 30 to 23, while from the cap from 30° to the pole the quantities are 25 to 10, on the same scale. Again the summer and winter proportions from 0°–45° and 45°–90° are 43 to 29 and 12 to 4 respectively.

The proportion of the summer and winter sunheats received by the entire hemisphere is obtained as 55 to 33, the unit being the same as before. That these two are almost exactly in the ratio of Ball's and Weiner's numbers, 63 to 37, may be regarded as a sufficient check on the accuracy of the figures, which were calculated separately.

E. P. CULVERWELL.

Trinity College, Dublin, November 25.

The Discovery of the Anti-Toxin of Snake-Poison.

IN reference to the statements contained in Prof. Ray Lankester's letter in your issue of December 12, I have to point out that no claim of priority has ever been advanced by me.

Hitherto my communications have been of the nature of preliminary statements, and in such communications it is neither possible to enter into details of the work done by others on the same subject, nor usual to attempt to do so.

On each occasion in which I have described the results of my experiments, I have briefly referred to all previous workers on the subject, in so far as they were known to me; and, in particular, I have definitely mentioned, or otherwise drawn attention to the circumstance that, before I had been able to do so, M. Calmette had published evidence showing that animals could be immunised against snake-venom, and that the blood-serum of those animals possesses antidotal properties.

At the same time, the work done by me was absolutely independent in its conception. It was originated several years ago, and has been carried out on a plan and with aims which were formed independently of the work of any other experimenter. That part of it which has as yet been described in the published abstracts had for the most part been completed before M. Calmette's paper announcing successful immunisation had come to my knowledge. I have rarely had occasion to consult Pasteur's *Annales*, and thus it happened that M. Calmette's paper was noticed only when the literature of a different and purely bacteriological subject was being collected for me. As to the articles in the *Contemporary Review*, I have not seen them, nor did I know of their existence until they were mentioned by Prof. Lankester.

THOMAS R. FRASER.

Edinburgh, December 16.

"Pithecanthropus erectus" and the Evolution of the Human Race.

THE remarkable advance made by biology during the last twenty years in the study of the Tertiary mammalia, must strike even the most casual onlooker. It is not merely that an exact knowledge has been gained of a vast number of extinct forms, but that amongst these has been discovered a profusion of missing links, rendering possible the construction of ancestral trees, or diagrammatic illustrations of the successive stages through which existing animals may have been evolved from a common stock. Some of these "trees" may prove to be mere intellectual weeds, which to-day are, and to-morrow are cast into the oven; but others are of robuster growth, finding a firm support in geology, which has been able in many cases to certainly fix the order in which successive branches of the tree have budded forth. It is to be regretted that geology has not been able to do more than this; could it but succeed in the construction of a scale of past time, what fascinating prospects in the study of evolution would be opened out! The construction of such a scale is beset, however, by grave—possibly insurmountable—difficulties, as will readily appear from the following attempt.

For the present there appears little hope of connecting geological events with such astronomical processes as changes of eccentricity and the precession of the equinoxes, and the only method left for our adoption is that of estimating the maximum thickness of the successive systems of stratified rocks. This, however, is to a great extent vitiated at the outset by the heterogeneous character of these systems; some are wholly or in part marine, some fluviatile; some consist largely of organic, others of mechanical sediment; and it is impossible to reduce their various members to any common term.

As there is no alternative, we proceed to do the best we can with existing materials, and shall now endeavour to obtain some approximate notion of the relative duration of the last three periods in the earth's history, viz. the Pleistocene, Pliocene, and Miocene. The first and most recent of these was probably of longer duration than we are accustomed to suppose. Borings sunk in the deltas of existing rivers have seldom penetrated to the bottom, yet they have indicated a very considerable thickness of deposits; thus, in the case of the Po, a boring near the Casa di Dio, Venice, passed through 572 feet of sediment. Near New Orleans, the delta of the Mississippi was penetrated for 630 feet; while the fluviatile deposits of the Ganges were shown, by a boring near Lucknow, to exceed 1336 feet in thickness. In Alaska, however, as the observations of Russell prove, the Pleistocene attains a far greater thickness than this ("Second Expedition to Mount St. Elias in 1891." U.S. Geol. Survey, Thirteenth Report, part ii. p. 24, 1891-2).

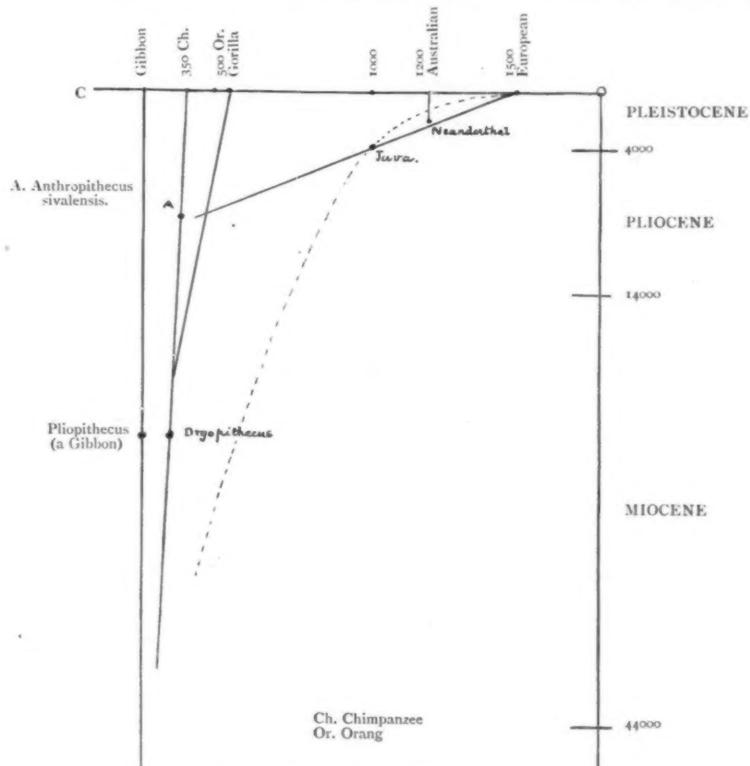
The following extracts from his report may prove generally interesting:—"The Chaix hills are geologically unique. They are formed of a monoclinal block of conformable strata eight or ten miles long, trending north-east and south-west, and tilted northward at an angle of 10° or 15°. . . . But what makes the hills especially interesting to the geologist is the fact that they are composed of stratified morainal material. . . . From many eye estimates it is evident that the minimum thickness of the deposit cannot be less than 4000 or 5000 feet. The rocks are essentially homogeneous from base to summit, and are composed of sandy clay containing large quantities of both angular and rounded boulders of all sizes up to six or eight feet in diameter. In the finer portions of the deposit . . . sea-shells are numerous. A small collection was made. . . . All [the species] are still living in the adjacent ocean. Besides the shells of molluscs, there are the shell-cases of annelids [*Serpula?*] attached to glaciated boulders, showing that the stones on which they grew must have remained exposed at the bottom of the sea for some time before being wholly buried."

It may be objected that these deposits differ so completely from those of the alluvial plain of the Ganges, in their nature and origin, that they might fairly be left out of account; but to this it may be replied that we have no reason for supposing that glacial denudation proceeds at a greater rate than fluviatile, indeed the reverse is probably nearer the truth, and though it is deposition and not denudation which is directly in question, yet the observation of Mr. Russell, that annelid tubes are found adhering to the embedded boulders of the deposit, certainly does not suggest an excessively rapid rate of accumulation. We shall take then 4000 feet as representing the maximum thickness of the Pleistocene system.

In a recent communication (NATURE, vol. li. p. 533) on the age of the earth, I gave 2000 feet as the maximum thickness of the Pliocene system, and this is the thickness which it attains in Europe (Sicily); but in India this is far surpassed, the Siwalik Hills, which are 14,000 or 15,000 feet in height, present for examination at least 10,000 feet of Pliocene deposits.

In Europe the Miocene does not exceed 6000 feet in thickness; but it may be regarded as quite certain that the duration of Miocene time was much greater than that of the Pliocene, and since in Europe the thickness of these two systems is as 3 : 1, we shall probably arrive at a just result if we take three times the thickness of the Pliocene of India to represent, on our scale, the duration of the Miocene period. We thus obtain for the proportional duration of our three periods the relation 0·4 : 1 : 3, which to the geologist has a veridical look.

In order to employ this scale to indicate the rate at which evolution in any particular case has proceeded, we must be able to give a numerical expression to the evolutional change also; and this can be accomplished, at least partially, in the case of the human race. For with it, the organ of organs is not so much the hand as the brain, and of this the volume at least can be ascertained, whenever we can possess ourselves of a human skull. In the following diagram the scale of time is plotted on the ordinate O T to the right, and the cranial capacity on the abscissa O C. The Neanderthal race is assigned to the middle of the Pleistocene, on the evidence of the Spy remains; the Java fossil is placed at the beginning of that period. Dr. Dubois is in possession of evidence which, when fully worked out, will fix its geological position with greater precision than we can attain at present; but so far as his published statements go, they point to that which we have assigned as the most probable horizon. The anthropoid apes are shown on the left of the diagram; the chimpanzee and gorilla are supposed to be the descendants of a chain of ancestors, which converge towards a common stem, on or near which Dryopithecus of the Middle Miocene is situated. This, which we may call the Dryopithecus stem, converges towards Hylobates. It will be observed that we have drawn all these lines of descent sloping towards the left, as they must almost certainly have done if there be any truth in evolution, and consequently the further back we go to find the origin of the human stem, the more brutal we make the primitive ancestor.



CRANIAL CAPACITY IN CUBIC CENTIMETRES.

If now we draw a line through the point occupied by the average European skull, and that occupied by the Javan skull, we find that it passes very close to the Neanderthal, and this suggests that the evolution of the human race has proceeded at a very uniform rate throughout the whole of Pleistocene time, while the excessive slope of the curve suggests that this rate was a very rapid one. If further we produce this line to the left, it will be found to intersect the ancestral stems of the highest anthropoid apes in the middle of the Pliocene period, and it is to this period that *Anthropithecus sivalensis* of Lydekker, a chimpanzee having affinities with man and Hylobates, has been assigned. The exact horizon from which the palate, on which this species is founded, was obtained is not known; and in this connection one is constrained to express the great regret that all biologists must feel at the imperfect manner in which the Siwalik strata have been investigated. Beds said to be unfossiliferous are known to possess fossils, and of those specimens which have been obtained from the series specially distinguished as fossiliferous, the proper geological position is not known. The Siwalik beds, if carefully searched, might be expected, from what we already know, to yield results no less precious to science than those obtained by Marsh and Cope in the famous deposits of the Green River Basin. It might be well worth considering whether an expedition could not be despatched from Europe for the special study of the Siwalik sediments.

The suggestion offered by the curve running through the apes to man is that he is of comparatively recent origin, and derivative from the stem of the gorilla or chimpanzee before these species had acquired their existing specialised characters. The straightness of the curve has an aspect almost miraculous, not a discommendation to the minds of some; but it has this positive advantage, that by linking on the human to the pithecoid stem at a high level, it saves us from the invention of a superfluity of imaginary predecessors, and all that tends to parsimony in this direction is an evident gain. The evolution along a line of descent is not confined to the acquisition of new characters, but includes the loss of others; and thus I can see no reason why the human ancestry should not have proceeded from the comparatively highly organised ancestors of the gorilla or chimpanzee, rather than from the more primitive predecessors of Hylobates. To those who think otherwise the curve shown by dotted lines will appear the more plausible; if the Neanderthal skull be lifted a little upwards in the scale of time, a curve can be made to pass through it, the European and Javan skulls, and this when prolonged downwards will approximate to the stem either of Pliopithecus (a Miocene gibbon) or the more brutal Dryopithecus. This would be a curve indicating greatly accelerated development as it approaches modern times; a contingency which a preliminary examination of other groups shows to be by no means impossible. Other curves no doubt could be drawn according to fancy of the individual; the true curve may possibly reward some fortunate investigator of the Siwalik Hills.

W. J. SOLLAS.

Globular Lightning.

A GREAT deal has been written recently on the various forms of lightning, and the subject itself has so much scientific interest, that it may be worth while to place on record an observation of my own on globular lightning, made years ago, in which the main facts are different from any I have seen described.

On Tuesday, July 23, 1878, I was on board a large yacht at anchor in the harbour of Southampton, England. About two o'clock in the afternoon, when we were about to sail, a violent thunderstorm came up from the west, and as it passed over Southampton, several bolts descended, one of which, as I afterwards learned, struck a church. As the first drops of rain came down on the yacht, I was standing in the after-companion-way, looking forward, when my attention was attracted by a bright light apparently near the upper part of the foremast. When I first saw it distinctly, it was about half-mast high, and was falling slowly and directly toward the deck. This light was a ball of fire, a delicate rose-pink in colour, pear-shaped in form, with the large end below, and appeared to be four or five inches in diameter and six or eight inches in length.

When it struck the deck, about forty feet from where I was standing, there was a loud explosion, and it was some minutes before it could be ascertained what damage had resulted. The mate, who stood near the mainmast, about twenty-five feet from where I was, was knocked down, but soon recovered. The same bolt, or part of it, also passed in front of the foremast, down a windsail ventilator, into the galley, where it knocked a large tin pan from the hands of a cook, and upset things generally throughout the culinary department, but injured no one seriously. Of the crew, some were on deck, and others below, but none were really injured, although a few were badly demoralised. A strong ozone-like odour was observed immediately after the explosion, and this remained perceptible for some time.

The officer in charge of the yacht, Captain Matthews, who was forward at the time, and escaped without injury, stated that just after the stroke, he saw "streaks of lightning running around on deck like snakes." I was myself only dazed for a moment by the explosion, and saw distinctly that the deck forward was illuminated with a bright confused light. The owner of the yacht, George Peabody Russell, and his other guests, had gone below when the storm began, and suffered no injury, except possibly from fright, as they were still further away from the stroke.

As soon as the storm had passed, I made careful notes of the whole occurrence, with drawings and measurements, as I was much interested in the subject, and it was the first instance of the kind I had seen at close quarters. An inspection showed that the vessel itself had sustained no material damage, and there were not even permanent marks left on the deck where the ball of fire exploded. A number of other yachts were at anchor quite near our vessel at the time, among them the white *Sunbeam*, just home from her well-known voyage, but we saw no indications that any of these had been struck. I had no time to inquire, as immediately after the storm we sailed on a cruise to the eastward.

O. C. MARSH.

Yale University, New Haven, Connecticut, December 4.

Large Human Femora in the Church of S. Eustachius, Tavistock.

TAVISTOCK ABBEY was founded A.D. 961 by Orgar, Earl of Devonshire, and endowed and completed by his son Ordulf A.D. 981. Some bones, said to have been found in an ancient stone coffin in the Abbey ruins, are locally believed to have once formed part of the skeleton of the said Ordulf, a reputed giant. According to William of Malmesbury, this Ordulf could stride across a stream ten feet wide, and he is said, by the same authority, to have torn off the bars from the town gate of Exeter with his hands, and to have wrenched away the hinges with his feet.

The relics, which are preserved under glass in Tavistock parish church, consist of three thigh bones which originally belonged to three different individuals.

Whilst at Tavistock recently I had an opportunity of measuring these bones: the extreme length of one is 1 ft. $9\frac{1}{8}$ in., the second 1 ft. $8\frac{3}{8}$ in., and the third 1 ft. $5\frac{1}{4}$ in. The heights of the original owners were therefore 6 ft. $8\frac{1}{2}$ in., 6 ft. $5\frac{1}{2}$ in., and 5 ft. $5\frac{1}{4}$ in. The two larger bones appear to have belonged to strong well-developed men, the other bone is more delicate.

Dunstable. WORTHINGTON G. SMITH.

A Lecture Experiment in Surface Tension.

WISHING to demonstrate to a fairly large audience the well-known disastrous results of attempting to remove grease stains by placing ether or benzol *on* them, instead of *round* them, and then spirally approaching their centres, I hit on the following plan, which gives not only unmistakable but beautiful results.

A circle of paraffin or olive oil is painted on the centre of a filter-paper, which is then dusted over with bone-black. A light blast of air on the paper removes the bone-black from all portions of the paper except the oiled portion, which looms up jet-black on a pale grey ground. The filter-paper is then folded in four wings, so that its edge forms a curved cross, and it is secured in this position by a penholder which has two longitudinal slits cut at right-angles. (This method of folding and securing will be familiar to all who can recall their school-days to the minutiæ of "penholder darts.")

The tip of the oiled apex of the filter-paper is dipped for a moment or two in ether. The paper is then unfolded, dried, and subjected to a second treatment with bone-black, when it will be found that the ether has chased the oil from the apex, and spread it towards the circumference of the paper in a symmetrical pattern.

It is scarcely necessary to add that there is no virtue in the special method of folding described above, and that a great diversity of beautiful patterns may be obtained by folding the filter-paper, and distributing the oil in other ways.

The Leys School, Cambridge. DOUGLAS CARNEGIE.

An Examination Question in Physics.

IN the subject of Experimental Physics, B.Sc. Examination for Honours of the University of London (December 5), the fifth question of the second paper stands as follows :—

"A plate of uniaxal crystal, cut with the faces *parallel* to the axis, is placed between a polariser and an analyser. How would you arrange a source of light and lenses to show a system of *rings* on a screen?

"Explain how the rings are formed when the polariser and analyser are crossed and the *axis is in the plane* of polarisation of the incident light." (The italics are my own.)

As the B.Sc. Honours is the highest examination of the University, the questions set therein are naturally regarded by students as important tests of knowledge; and I think it would, therefore, be of considerable scientific interest if the examiners would kindly state their intention in setting this question, and the nature of the answer they expected to receive.

Queen's College, Harley Street, W. E. F. HERROUN.

"Linotænia maritima" (Leach).

WILL you kindly allow me to put on record a new locality for this marine centipede?—Bexhill, just above high-water mark. The single specimen taken was kindly identified for me by Mr. R. I. Pocock, of the British Museum (Natural History).

HENRY SCHERREN.

9 Cavendish Road, Harringay, N.

THE TRANSFORMATIONS OF INSECTS.

SO much special work has been done during the last thirty years upon the transformations of insects, that I lately resolved to spend some time in reviewing the most important facts which have been ascertained respecting the structural changes which take place before or during pupation. I had not gone far before I found it necessary to clear up my own thoughts as to the nature of insect metamorphosis, and the way in which it had come about. Some preliminary considerations upon these points, inferred from facts which have long been known, I now propose to discuss, leaving the more special facts to some future occasion.

Three naturalists, Fritz Müller (1864),[1] Friedrich Brauer (1869),[2] and Sir John Lubbock (1874),[3] have in

[1] "Facts for Darwin" (Für Darwin).
[2] *Verh. Zool. bot. Ges. Wien* (1869). Of less importance is Part 2 (1878).
[3] "Origin and Metamorphoses of Insects." (Appeared originally in NATURE, 1873).

our own time written upon the origin of insect transformations. It was, as they themselves tell us, Darwin's "Origin of Species" which incited each of them to look at the old facts in the light of a new theory. Fritz Müller, being at the moment specially occupied, not with insects, but with crustaceans, threw out casually, as it were, a number of general results of the greatest interest and value, which he did not attempt to support nearly so fully as his own knowledge of insects would have enabled him to do. Brauer, a little later, travelled over the subject in a somewhat more leisurely way. The most important principles had already been indicated by Müller, but he was able to contribute many facts of special interest, and to point out a definite and rather widely distributed larval stage, of which much has since been said in discussions on the phylogeny of insects. I need not remind English naturalists that, even before 1874, Sir John Lubbock had won fame by his researches into the life-history and habits of insects. He had also written specially upon insect transformations before he collected his matured thoughts into a book. His "Origin and Metamorphoses of Insects" is now very widely known. It is by far the most readable exposition which we possess, and will long hold its place as an interesting account in simple language of that part of the subject which involves no special knowledge of insect anatomy. Some day it should be supplemented by an account of the mechanism of pupation, showing in detail how various larvæ are converted into winged insects. It is on this side that insect transformations have been most successfully attacked during the last thirty years.

It is natural that after an interval of many years we should find what seem to be deficiencies in the work of those who have gone before us. The most notable deficiency which I find in Lubbock's book is that he does not remark the great distinction between insect metamorphoses and those of most other animals.[1] They occur, as I think, in a different part of the life-history, and arise out of conditions which are different, or even diametrically opposite. There are other points, too, which seem to me to be passed over too briefly by Lubbock and all previous writers. In particular, certain aphorisms of Fritz Müller seem to me to deserve a fuller explanation than they have yet received.

Such inevitable gaps in the expositions of our predecessors render it possible to supplement even works which have attained the rank of classics. Each generation for a long time to come will be able to add its quota of facts and reflections without exhausting this immense and difficult subject of inquiry. It is satisfactory to note that Lubbock's account has been very little disturbed as to matters of fact by later investigations, so that his readers, though they have plenty still to learn, have very little to unlearn.

Let me first attempt to justify my contention that the transformations of insects are fundamentally unlike the transformations of polyps, echinoderms, mollusks and crustaceans. In the marine groups the minute animal, just escaped from the egg, passes rapidly through its changes, often before the yolk is absorbed. It may complete them before it begins to feed, always long before it has attained its full size. The insect, on the contrary, undergoes its most striking change of form after it has attained its full size. Moreover, the planula of the polyp, the bipinnaria or pluteus of the echinoderm, the Nauplius or Zoæa of the crustacean, are unknown except as transitory forms. But the less specialised insect-larvæ make a very close approach to certain lower, wingless insects in their adult state. The insect-larva, before it gives place to the pupa, has not only attained its full size, and acquired a form answerable to that of some perfectly adult insects, but it already contains in many cases completely developed reproductive products; indeed, a very few insects are known to be capable of reproduction as larvæ. It seems to me preposterous to say, as Harvey did in the 17th century, that the insect-larva is a kind of walking egg, or with Quatrefages, that it is an embryo which leads an independent life. It would be far more truthfully described as an animal which has attained the normal structure of adult Arthropods, though it has still to undergo a peculiar adult transformation. Where the insect larva falls short of that adult structure, it is because abundance of food, or some other external circumstance, has induced degeneration, but we shall best understand insect-larvæ in general by comparing them to sexually mature myriopods, protracheates, scorpions and Thysanura.

Adult transformation is rare among free-living animals, though parasites furnish many examples. The Ctenophora, instead of settling down early, maintain a pelagic life, and became specially modified thereto in a late stage of development. The secondary sexual characters assumed by some birds and mammals at the time of sexual maturity, such as the train of the peacock, or the antlers of the stag, are analogous facts. But the closest parallel to the transformation of insects is to be found in the Amphibia. Frogs and toads, having already as tadpoles attained the full development of the more primitive Amphibia, change to lung-breathing, tailless, land-traversing animals. The motive is the same as that which led to the acquisition of wings by insects. It is by virtue of their adult transformation, that both the amphibian and the insect are enabled to wander from the place of their birth, to seek out mates belonging to other families, and to lay their eggs in new sites.

In those Amphibia which undergo transformation, the stage added to the life-history of the more primitive forms is not the tadpole, but the frog or toad. In those insects which undergo transformation, complete or incomplete, the winged state is the new addition. If a pupa appears in the life-history, it results indirectly from the acquisition of wings by the adult. Hence it seems to me that in Amphibia and insects the peculiar change, which renders possible all the rest, belongs to the adult condition, *i.e.* these animals undergo an *adult* metamorphosis.

Transformation in the inhabitants of the shallow seas is closely related to the crowded state and severe competition of the area. The connection is two-fold. Unusual risks imply numerous eggs, numerous eggs must be small, and small eggs, with little or no yolk, hatch early, producing very immature animals, unlike their parents. Again the risks of the shore favour heavy-armoured species, and it is well-known that a great proportion of the invertebrate fauna of the sea-shore is defended in this way. But heavy armour diminishes activity, and in particular often renders swimming impossible. The dispersal of the species is therefore left to the young fry, which are often specially organised for locomotion at the surface of the sea. Marine animals which are not armoured, such as the Cephalopoda, may undergo no transformation at all.

Certain general propositions concerning larval transformation are disturbed if the adult transformation of insects and Amphibia is included. Indeed, I was first led to notice the distinction between adult and larval transformation by observing that insects and Amphibia do not conform to the general rule, that while the inhabitants of the shallow seas go through transformations in early life, fluviatile and terrestrial animals do not.

Every animal and every plant has these two functions

[1] I am not aware that any one else has made more than a passing allusion to this distinction, but I may easily have overlooked some important reference in the vast literature on insect transformations. Macleay has remarked that in insects the change of form takes place during their last two or three stages, whereas "the metamorphosis of all other Annulosa only occurs during the first or second moult after leaving the egg." (*Illustr. Zool. South Africa*, p. 53). I do not find this distinction recognised as part of ordinary biological knowledge in our best treatises on development, such as Balfour, or Korschelt and Heider.

(among others) to fulfil. It must feed and grow; it must also separate from its fellows, and find out an unoccupied site. The two functions may be discharged together. Birds, for instance, feed all round the year, and change their abode whenever they suffer from overcrowding or scarcity of food. In other cases, either function may for special reasons be limited to a particular time of life. The crustacean cannot migrate effectively when adult, because of the heavy armour which it carries. The insect cannot migrate effectively when young, because of the difficulty of travel by land. It is easy for a minute animal to travel by sea. The high specific gravity of the water renders the body buoyant, and currents, even where special locomotive organs are absent, will do the work of transport. Power to rise and sink in the water is convenient, but even this is not strictly indispensable. On land the conditions are very different. The weight of the body has to be supported in a comparatively rare medium, and much greater exertion is called for. Running, leaping, and flying are difficult exercises, much better performed by the adult than by the larva, if these should happen to differ materially.

It is often of advantage that there should be division of labour between the several stages of the life-history, and the functions of migration and growth may be allotted to special times of life instead of being carried on throughout. Migration is naturally associated with lightness and activity; feeding and rapid growth are favoured by a sedentary habit. If such division of labour should take place, as it commonly does in crustaceans and insects, the crustacean will find it convenient to perform its migration early, when it has little armour to carry, and when its surface is large in proportion to its weight. The Zoæa will do little more by its own exertions than maintain the right attitude and the right distance from the surface of the sea, leaving the currents to effect the actual transport from place to place. Migration over, it will settle to the bottom, acquire heavy armour as a defence from its many enemies, and begin to feed in earnest, becoming in the end a slow and heavy inhabitant of the sea-bottom. With the insect the procedure will be reversed. Being unable to travel far while small and weak, it will feed first, and having attained its full size, will then, if at all, acquire special means of locomotion. Wings are more efficient as a means of transport than any other organs of locomotion of which a terrestrial animal can avail itself; but flight is so difficult an exercise that wings, if acquired at all, will be acquired late.

Marine animals commonly produce far more eggs than insects.[1] The risks of the shallow seas are so great that a small proportion only of the young animals comes to maturity. Hence the enormous fertility of common marine animals, except such as are able to nourish or defend their young. Where a vast multitude of eggs hatch out together, dispersal in search of food becomes an immediate necessity.

The more sluggish and sedentary the adult, the greater the activity we may expect to find in the larvæ. It is they which have to travel and to find out suitable quarters. But they often make up by their numbers for any deficiency in enterprise or intelligence. Vast numbers of Zoæas are swept into mid-ocean or into tidal rivers, or are devoured. It is only a chance remnant that survives.

Just as the sluggishness of the adult crustacean or echinoderm may promote activity in the young, so the activity of the adult insect may discourage activity in the young. The power of flight possessed by most adult insects favours a sedentary life in the larva, which is spared all effort in connection with the dispersal of the species, and can give its undivided attention to feeding. Accordingly the larva often degenerates more or less, especially when its food is abundant and obtained without labour or risk. The sagacity and industry of the bee in storing its cells with honey may be said to have cost the larva its legs. So, too, the active and highly-gifted blow-fly, ichneumon, and gall-fly secure abundant food for the new generations, which emerge as footless grubs. In the Coleoptera we find that the larvæ, which feed on dead vegetable matter beneath the surface of the ground, are heavy-bodied and short-legged, sometimes so overloaded by the weight of the abdomen that they rest lying on one side. The larvæ of weevils, which are vegetable-feeders and often buried in the plant which they devour, are commonly without legs altogether. Even the head of the larva may be reduced almost to nothing by the labours of the adult insect. The blowfly finds out a practically inexhaustible supply of carrion in which to lay its eggs, and the larval head is so reduced that it consists mainly of a pair of large hooks, with muscles to work them, and a chitinous frame to form a fulcrum for the muscles.

The degeneration of the larva can only proceed far when the adult undertakes the dispersal of the species. That is why, it seems to me, the larvæ of marine animals, though often very unlike their parents, are not really to be called degenerate. They cannot be supposed to have arisen from ordinary forms, typical of the class, by mere disuse and reduction of the organs of active life. On the contrary, they are often immature forms specialised for locomotion.

Even when the adult undertakes the dispersal of the species, the larva does not necessarily become degenerate. The winged locust is the chief agent in dispersal, but the larvæ are active, seek their own food, and exhibit no marks of degeneration. It is only when their choice and responsibility are taken away, when they are encouraged to feed almost without intermission, or to bury themselves out of sight, that they degenerate.

Parental care and all labours undertaken by the parent for the sake of the offspring tend to promote helplessness in the young. The helplessness of the higher Vertebrates at birth, as well as their prolonged fœtal development, are due to the fact that their parents are able to find them food and protection. Here there is no degeneration in the young; though helpless, they are of the same zoological grade as their parents. The locomotive organs and the senses of a baby or a nestling bird are as complex as those of the adult, and are merely feeble for want of skill and exercise. In the larval insect there may be real degeneration, fewer limbs, fewer joints in the limbs, deficiency of sense-organs, relative preponderance of the organs of nutrition. If the transformation of insects had never been traced, the structure of the two stages would have inevitably led zoologists to place the caterpillar in a lower class or order than the butterfly.

There has been much speculation as to the form of primitive insects. Fritz Müller supposes that the wingless Orthoptera come near to the original stock, while others have derived all insects from the wingless and non-metamorphic Thysanura. By taking what is common to the least modified Orthoptera and the Thysanura, and rejecting all features peculiar to either, we shall certainly get a highly generalised insect, such as might possibly be a common ancestor for the whole group. Brauer pointed out that such primitive insects still survive in Campodea and Japyx, which have mouth-parts (as Lubbock considers) "intermediate between the mandibulate and haustellate types," one pair of many-jointed antennæ, three pairs of long legs, and an abdomen whose first seven segments bear pairs of rudimentary appendages, while the tenth and last segment bears in Campodea a pair of many-jointed appendages, in Japyx

[1] No statistics have been collected to my knowledge on an extensive scale. Very many insects lay their eggs singly. In particular cases (social insects, Meloidæ, &c.), where special reasons obtain, they may be laid in great numbers, but my general impression is that the eggs of Echinoderms or marine Crustaceans would be far more numerous as a rule.

a forceps. Campodea and Japyx have no eyes, but this is not considered typical; simple eyes are usual in insects of the same grade. They undergo no metamorphosis.

Brauer finds forms closely resembling Campodea among the larvæ of Orthoptera, Perlidæ, Odonata, Ephemeridæ, Coleoptera and Neuroptera. In Strepsiptera and Coccidæ he considers that they are present in a more modified form. No Campodeiform larvæ occur among Lepidoptera, Hymenoptera, or Diptera.

Brauer looks upon the caterpillar of Lepidoptera, Sawflies and Panorpa as a degenerate Campodea, while he considers the apodous maggot of many Coleoptera, some Neuroptera, Bees and Muscidæ as a still more degenerate larva, derived from, and not historically antecedent to, the Campodea. Grassi and others have brought forward facts to show that the maggot-like Bee-larva has previously passed through a kind of Campodea-stage.

Lubbock regards the caterpillar too as essentially a Campodea. But this extension seems to me to take all definiteness out of the Campodea-form. If every larva with biting mouth-parts and six legs is to be called a Campodea, we still want a name for the larva which has long legs, long antennæ and at least one pair of abdominal appendages.

Brauer's Campodea seems to invite comparison with Scolopendrella and Peripatus; just as the more generalised Campodea of Lubbock invites comparison with the hexapod larva of Diplopoda and Atax. I do not venture to pursue these comparisons, which involve difficulties not apparent at first sight, and will only remark that the former comparison seems to throw most light upon the phylogeny. The leg-bearing segments of the Diplopoda are apparently not the same as those of insects, and the embryology of insects points to a polypod, rather than to a hexapod, as the common ancestor of the Tracheates.

If it seems rash, with our present knowledge, to trace the phylogeny of Peripatus, the Myriopods and the insects, what shall we say of Lubbock's far bolder attempt to derive his Campodeiform larva from a Rotifer-like ancestor? It is suggested, though not positively asserted, that certain apodous dipterous larvæ exemplify this earlier stage. I must declare myself altogether sceptical as to a Lindia-stage antecedent to the Campodea. The only apodous insect-larvæ known to me are born of highly specialised insects, and have apparently become degenerate in consequence of the completeness of the provision made for them by the intelligence or special instincts of the parent. They are, as Brauer humorously says, like the sluggards in Hans Sachs' Lubberland, who required roast pigeons to fly into their mouths. I see in them no mark of a primitive insect.

Brauer in 1869 was ready to derive the maggot from the caterpillar, and the caterpillar from the Campodea (p. 310). He points out, very truly, that the reduction of the larval head of the Diptera may be gradually traced from forms in which it is perfectly developed. It is a pity that he did not bear his own explanation in mind when at a later date he attempted to arrange the Diptera Nemocera by characters largely drawn from the degree of development of the larval head. The unsatisfactory nature of the result has been pointed out by Baron Osten Sacken (*Berl. Ent. Zeits.*, Bd. xxxvii. p. 417, 1892).

That Brauer's arrangement of the Nemocera does not, in the opinion of experts, associate allied forms, shows that he has been unfortunate in his use of larval characters. Could that result have been anticipated? Is there any general objection to the employment of larval characters in the definition of large groups of insects? I think that there is. In his paper of 1869 Brauer, following Fritz Müller, remarks that the development of various insects has been either abbreviated or falsified. He thinks that the Hemiptera have lost a transformation which they once possessed. He thinks that Dipterous larvæ and others have been acted upon by conditions of life which have not affected the imago. Yet he has employed characters which he knew to be highly adaptive and also finely gradated, for the definition of his tribes and families. Brauer is both a systematist and a philosopher, but his system forgets his philosophy.

Primitive insects, we may suppose, attained the Campodea form in the egg, after which they merely increased in size without important modification of structure. The next step opened the way to extraordinary developments, which were not, however, immediate or necessary consequences. Certain insects acquired wings as adults, while others remained wingless and pursued the old life. The acquisition of wings did not as a matter of course greatly affect the habits of the species. Some, like the grasshoppers, crickets, and cockroaches of to-day, continued to run about on their long legs in all stages, and divided their food with the same kind of jaws as their wingless progenitors. But when full advantage was taken of the new means of locomotion, the life-history was profoundly affected, the two extremes, early and late, being acted upon in opposite ways. The imago grew more active and quicker to discover the best sites for egg-laying, gradually undertaking the whole function of dispersal of the species. The larva, thus relieved from choice and travel, became slow and clumsy, escaping its enemies by protective resemblance or burrowing. It came to be more and more exclusively occupied with feeding, while the adult, except where the business of egg-laying was unusually protracted, fed less and less, sometimes not at all.

The quiescent pupal stage seems to me to have arisen from the contrast between the degenerate, slow, voracious larva and the active, highly organised and sensitive imago. Sagacity and activity gradually declined in the larva, and became exalted in the imago, until the extremes of the life-history became so unlike that they could only be reconciled by profound changes, incompatible with locomotion and feeding.

I quite agree with Lubbock's remark, "that the apparent abruptness of the changes which insects undergo, arises in great measure from the hardness of their skin, which admits of no gradual alteration of form, and which is itself necessary in order to afford sufficient support to the muscles." The hardness of the skin in insects and other Arthropods involves periodical moults in order that the body may increase in size. Pupation is an exaggeration of one of these moults, the subsequent escape of the imago is an exaggeration of another. These two moults are the last but one, and the last of all, and the pupal stage, where there is one, intervenes between them.[1] An ordinary moult gives opportunity for effecting slight changes in the chitinous cuticle. The new skin is not necessarily moulded precisely upon the old one. If increase of size is required, the new skin can be made a little larger, and accommodated within the old one by wrinkling or folding. It is in this way that the wings of an Ephemera, a dragon-fly, or a male cockroach gradually attain their full size. If projections of unusual length are to be formed beneath the old skin, they can easily be telescoped into the body; a process which attains a high degree of complexity in some insects.

Many insect transformations, too familiar to be detailed here, illustrate the great facilities afforded by the change of skin for replacement of organs lost by degeneration, or for development of new ones, more elaborate than any possessed by primitive insects. But for these facilities I imagine that larval degeneration would never have gone so far as it has done in insects; the price to be paid would have been too heavy.

[1] It has come to pass, by some process which I cannot trace, that in Ephemeridæ, where there is no pupal stage, the fly quits the water at the last moult but one, and immediately afterwards casts another very thin skin.

How insects first acquired wings, and from what structure they were derived, is still a profound mystery. A favourite conjecture is that they arose by the modification of tracheal gills. In favour of that supposition is the fact that in some dipterous larvæ (Chironomus, Simulium, Culex, Muscidæ), three pairs of rudiments (imaginal folds) form on the dorsal surface of the thoracic segments, and as many on the ventral surface. The ventral rudiments ultimately become the legs of the fly. Of the dorsal rudiments the second becomes a wing, the third a rudimentary wing, and the first the respiratory organ of the pupa, which may take the form of a trumpet or a bunch of branching tubes. In the larvæ of the Muscidæ this anterior dorsal appendage is said by Weismann to form much later than the rest, only during the last larval stage, and to be greatly inferior in size. In Chironomus and Simulium it forms at the same time, and is quite similar to them. Where an anterior spiracle exists, as in the Muscidæ, the anterior dorsal appendage forms close behind it, and ultimately replaces it. Now, if it could be clearly shown that all three dorsal appendages form one series, and that one or two are converted into wings, while the foremost becomes a breathing-organ, we should at least know that a wing and a breathing-organ may have a common origin. So much seems probable, but we must still wait for conclusive facts before we can explain how insects first got their wings.

In many Orthoptera, and other hemimetabolic insects, effective wings are developed without any resting-stage. I think that we may safely infer that historically wings were acquired before complete metamorphosis set in, and before insect-larvæ underwent degeneration.

Though the fact must, of course, be well known, I do not remember that any zoologist has expressly mentioned that the resting-stage of insects is unique among animals. The nearest phenomenon of the same kind is the encystment of certain Protozoa and parasites; but cessation of all the functions of active life, when these have once been assumed, for the purpose of effecting a definite advance in organisation, is a thing peculiar to insects. Hence we cannot check our interpretations by examples taken from outside the class. But all insects do not pupate, and we may learn something by studying the hemimetabolic insects in which there is no quiescent pupa.

Nearly all these insects (some few Orthoptera and some Rhynchota are exceptions) ultimately acquire wings, the rudiments of which may be externally visible long before the imago stage is reached. In hemimetabolic insects it is unusual to find any marked change in the food, the mouth-parts, the general form of the body, the texture of the skin, the length of the legs, the muscles, or the nervous system. It is often difficult to distinguish a full-sized larva from the imago without close examination. In Ephemeridæ, Perlidæ, and Odonata the larva is aquatic and the imago aërial, so that notable changes appear in the mode of respiration, but still the transition is effected without a resting-stage.

We have seen that wings may be acquired by insects which pass through no pupa-stage. There is, however, hardly a case (the parasitic flea is one) of an insect which pupates without acquiring at least the rudiments of wings in one or other sex. The main purpose of pupation would in general be defeated if the adult were wingless.

Change in the form of the mouth-parts, if so considerable as to involve a new method of feeding, *e.g.* the substitution of sucking for biting, cannot be effected without a quiescent pupa-stage. It seems inevitably to involve a rather prolonged interval during which the old mouth-parts are not in working order, while the new ones are not yet complete. But though considerable changes in the mouth-parts imply a quiescent pupa, they are not the sole reason for pupation. The larva and imago of many Hymenoptera and Coleoptera have similar mouth-parts, yet they all pupate. Neither acquisition of wings nor great changes in the mouth-parts can be the sole reason for pupation, for pupation is not indispensable to acquisition of wings, and it is not always followed by material changes in the mouth-parts.

Lubbock quotes from his earlier memoir on Chloeon (*Linn. Trans.*, vol. xxv. p. 486, 1865), the remark "that the occurrence of metamorphoses arises from the immaturity of the condition in which some animals leave the egg." Insects are specially referred to, for in the memoir quoted we are told that the necessity for change depends on the fact that most insects leave the egg in a very early condition, and that this again is probably owing to the fact that the amount of nourishment in the egg is insufficient to carry the insect to maturity. Brauer adds that the eggs of insects with complete metamorphosis are regularly smaller in proportion to the parent than those with incomplete metamorphosis or none.

I believe that Lubbock's explanation is true of many marine invertebrates, but not of insects. The vast number of eggs laid by a crab or a sea-urchin is very likely one cause of the smallness of the eggs and of the unlikeness of the larva to the parent. The transformation which assimilates the larva to the parent is in such cases effected as soon as possible after the migatory larva has settled down and begun to feed. But in the insect there is, as a rule, no important advance in structure during almost the whole of the larval period. If deficiency of nourishment had occasioned a temporary arrest of development, abundance of nourishment would surely have made up the loss sooner. The time of pupation seems to me too distant from the time of hatching, especially as the whole period of active feeding and rapid growth intervenes, to be entirely due to the conditions of nourishment of the larva in the egg. Special facts, of which many could be cited, tell against Lubbock's explanation. The Staphylinidæ commonly lay relatively large eggs, and yet undergo complete metamorphosis. Some insects actually retrograde before hatching out, and lose legs which they had already acquired, a pretty clear proof that want of nourishment was not the cause of what is called their immaturity at birth. The state of the insect at hatching seems to me to depend far more upon the conditions of larval life than upon the supposed privation of nourishment during embryonic development.

It is plain that insects have gained very much by complete metamorphosis. The extraordinary numbers and range of the holometabolic insects settle that fact decisively. If further proof were required, we might point out that the resting-stage or quiescent pupa seems never to have been lost in any insect which once possessed it. It is hard to prove a negative, but I cannot call to mind a single clear instance. So powerfully has adaptation acted upon insects that almost every organ and almost every stage is known to disappear at times. Wings, legs, eyes, mouth-organs, head, are known to be deficient in the larva, and a very few adult insects have no functional wings, legs, eyes, or mouth-organs. The single order Diptera furnishes us with examples of suppression during the larval stage of all these organs. The egg, the larva, the winged imago may disappear as independent stages in the pupiparous Diptera. But the quiescent pupa remains in every case where it can be shown to have once existed. At most the pupa (in holometabolic orders) becomes in some degree capable of locomotion; it never feeds.

We cannot reckon among the advantages secured by complete metamorphosis the acquisition of wings, for many insects which acquire wings have passed through no resting-stage. Among these hemimetabolic insects are the dragonflies, which take their prey on the wing, but in general the hemimetabolic insects gain nothing by flight, except facilities for dispersal and egg-laying.

The female ant, and apparently the Ornithobia, lay aside their wings as soon as the eggs are fertilised. In adult hemimetabolic insects the mouth-parts are either like those of the larva, or not functional at all; the form of the body, the texture of the cuticle, the organs of sense, and the legs are in general those of the larva, so that we might consider the imago as merely a winged and sexually mature larva.

But the imago of the holometabolic insect is always more than a winged and sexually mature larva. It differs in the form of the body, in the internal anatomy, in the organs of special sense, and usually in the structure of the mouth-parts. Perhaps the smallest advance upon the larva is seen in the imago of the Adephagous Coleoptera, but even here, though the mouth-parts are generally similar and the wings often rudimentary, the difference between the adult and the larva is much greater than in a locust, cricket, or cockroach. Some anatomical comparisons which I have made between the larva and imago of the Carabidæ, point to great changes in the muscular system as sufficient to explain th› retention of the resting-stage even in the absence of other motives. The changes in the muscular system are rendered necessary by extensive changes in the shape of almost every segment and every appendage. But the reason of these changes of shape is sometimes hard to discover.

The greatest advantage won by holometabolic insects is access to the pollen and honey of flowers. Both flowers and insects benefit by mutual help, and have become specially modified to make the most of it. Perhaps no ametabolic insect regularly visits flowers. Some small Hemiptera, which are hemimetabolic, do so, but I believe that their visits have not called forth any special adaptation on either side. The Coleoptera, though holometabolic, have biting jaws, and this may be the reason why so few of them regularly haunt flowers. Hermann Müller tells us that some tropical beetles have the maxillæ specially modified for honey-sucking.

Three large orders of highly-organised insects contain a greater or less number of honey-sucking species. These are the Diptera, the Hymenoptera, and the Lepidoptera. The honey-sucking Diptera are comparatively few, but they are of importance to flowers, many of which depend upon their visits for the fertilisation of their ovules. The honey-sucking Hymenoptera are the bees. Of all insects these make the greatest use of honey and pollen, feeding upon it throughout life; they exhibit a more elaborate collecting apparatus, and have acted with more effect upon the organisation of flowers than any other insects. In Lepidoptera honey-sucking becomes more frequent than in any other order. Every moth and butterfly that feeds at all sucks honey, to pass over such unimportant exceptions as the fruit-eating moths with perforating proboscis.

It is a striking proof of the importance of insects in nature that they should have been able to call into existence a profusion of beautiful flowers. All the flowers of the garden and conservatory, all the wild flowers which delight us by their perfume, colour, or form, are in a sense the work of insects. What they found ready to hand was a multitude of green or sober-tinted flowers of small size, without honey or scent; the visits of insects have done all the rest. Flowers have done almost as much for insects as insects have done for flowers. Flowers are to innumerable tribes of insects all that domestic animals and cultivated plants are to mankind. Honey, which may be considered a joint product of the flower and the insect, owes its great importance to three properties. It is fluid, it is highly nutritious, and it can be stored without undergoing putrefaction. Its fluidity and concentration render it particularly suitable as a food for those winged insects which lay their eggs singly or a few together on scattered plants of one kind, and which must, therefore, spend much time in egg-laying, as well as to those which spend much time in excavation or building. Upon the fact that honey can be stored for many months depends the whole domestic economy of many species of bees and ants. The chemical possibility of the conversion of honey into wax was a discovery made by bees to the great advantage of their architecture. Not only have special instincts been founded upon the properties of honey, but its pursuit has led to increased swiftness on the wing, keener perception of colour and distance, as well as to obvious modifications of mouth-parts and stomach.

Like other facilities which encourage activity and intelligence in the adult, honey-sucking tends to arrest the development of the larva. The parent undertakes all responsibility and labour, and leaves the young with nothing to do but to feed and grow.

Honey-sucking is associated, but not rigidly or indispensably, with the highest faculties ever attained by insects. It marks, perhaps, the highest phase in their evolution. No insect can get so high without passing through a quiescent pupal stage, for without metamorphosis it cannot acquire organs of sufficient delicacy. Those which attain to honey-sucking have within their reach all the accomplishments and all the civilisation of which any insect is capable.

To any one who considers the great importance of honey in the life of the higher insects, it is a surprise that ants should have climbed so high without honey-sucking. They have biting jaws, and the workers have no wings. Hence they are useless for the fertilisation of flowers, and many flowers have developed elaborate obstacles for the express purpose of excluding ants. Ants, however, do supply themselves with honey in spite of all obstacles. They will get it from Aphides if no better way can be found. Some ants have learned to store honey in subterranean receptacles, the most singular of which are the enormously dilated crops of certain individuals of the community, which sacrifice themselves for the good of the rest, and are converted into enormous, globular honey-pots. The Myrmecocystus of Mexico, and the Camponotus of Australia, furnish us with examples.[1]

It would seem as if ants had sacrificed their wings for the sake of carrying on their subterranean life with greater ease. They have paid a heavy price for this advantage, for loss of wings in the end involved exclusion from flowers. The bees have managed to keep their wings, and yet to build elaborate structures for the family.

Beginning with the Campodea form, insects have ascended through several degrees of specialisation, acquiring first wings, then complete metamorphosis, and lastly attaining to honey-sucking. They have also descended through equally marked stages, losing length of limb first, then losing their limbs altogether, and in extreme cases losing their heads and jaws almost completely. The highest perfection of the insect-type is always found in the adult, the lowest degeneration in the larva. To the intervention of the resting-stage is due a singular relation between the two processes of evolution and degeneration, which is, as far as I know, peculiar to insects. In insects, as a general rule, the higher the organisation of the adult, the lower the degeneration of the larva. The complete metamorphosis of the Coleoptera, Lepidoptera, Hymenoptera and Diptera has rendered it possible for their larvæ to degenerate, and yet recover in a later stage all that has been lost. The grubs of the weevil and the bee would not have lost their legs if the parent had been unable to provide them with a store of food sufficient for the whole larval period, which could be devoured without leaving the place of hatching. The maggot would not have lost head and

[1] Lubbock, "Ants, Bees, and Wasps," p. 19.

jaws if the fly had been unable to lay its eggs in an abundant supply of highly nutritive food.

The illustrative table will render it easier to realise that in insects as a general rule, special development upwards involves special development downwards in an earlier stage, and also that only a very moderate difference between the extreme forms of the larva and the adult can arise without a resting-stage. Abundance of food, and a life without exertion, often render the larval skin soft and extensible. Since in insects the chitinous cuticle furnishes a chief part of all the organs of locomotion, of prehension, and of special sense, a soft, extensible skin involves complete degeneration. This may last throughout the whole larval period, during which the external conditions are usually the same. Then comes the sudden change to a stage in which a maximum of activity and intelligence is called for.

EVOLUTION AND DEGENERATION OF INSECTS.

	Thysanura	Orthoptera	Coleoptera (Adephaga)	,, (Lamellicornia)	,, (Weevils)	Hymenoptera (Saw-flies)	,, (Bees)	Lepidoptera	Diptera (Nemocera)	,, (Muscidæ)	,, (Syrphidæ)
Honey-sucking							.	.			.
Complete metamorphosis			.	.	.	.			.	.	
Wings		.									
Campodea	.	.	.								
Legs reduced				.		.		.	.		
No legs					.		.				
Head reduced										.	.

It will be evident to those who have previously studied the subject that Fritz Müller has been my chief guide in this discussion. We owe much both to Brauer and to Lubbock, but I think that we owe to Müller, and indirectly to his master, Charles Darwin, the most considerable advance in the philosophy of transformation that has been made for two centuries.

L. C. MIALL.

LUDWIG RÜTIMEYER.

THIS distinguished naturalist was born at Biglen, in the Canton Bern, in 1825. His father was the parish clergyman, but was shortly afterwards made superintendent of the Orphanage at Bern. Here Ludwig, when old enough, attended the High School, going when sixteen years of age to the Gymnasium. At this time he made the acquaintance of Bernhard Studer, and with him made several excursions to the surrounding Alps. In 1843 he entered the University of Bern, with the intention of following his father's profession, and for some years devoted himself to theological studies; but all the time he seems to have been more or less attracted to the study of natural history, and, as we believe, partly influenced by the companionship of Peter Merian (the well-known palæontologist of Basel, born 1795), Rütimeyer took up the medical faculty about 1848, and for the rest of his life devoted himself to to the study of comparative anatomy. He soon extended his travels, and we find him in 1850 at Paris, where, among many others, he met Elie de Beaumont. In 1851 he visited the south of France and Italy, going as far as Palmero. In 1852 he came to London, and made the acquaintance of Owen and Murchison. Returning to Bern, he published "Vom Meer bis zu den Alpen," the substance of which he had given as a course of popular lectures. He filled the post of teacher in the Technical School, and seems at this period of his life to have had the not unusual struggle in striving to make both ends meet. He married in 1855, and through the influence of Peter Merian he was appointed to the recently-founded chair of Zoology and Comparative Anatomy at Basel, which post he held until his death, which took place on the 26th of last month.

It is not necessary to give a list—it would be long one—of Rütimeyer's published works. He was scarcely settled at Basel before memoir after memoir came from his pen. One of the earliest, laid before the Natural History Society of Basel, was "On Recent and Fossil Swine," showing then the tendency his thoughts were taking. Perhaps the work by which he will be the longest remembered by, will be "Die Fauna der Pfahlbauten in der Schweiz." In this quarto volume we have a careful series of researches into the natural history of the wild and domestic mammals of Middle Europe, which attracted great attention at the time, from the preciseness of its details and the wideness of its speculations. It was published in 1861, a couple of years after the first publication of "The Origin of Species"; but many of the details had been laid before the Society of Antiquaries of Zürich in the previous year, and the author was fortunate in having the assistance of such investigators as Keller, Morlot, Uhlmann, Troyon, and Forel.

Personally Rütimeyer was extremely amiable; he was a good teacher, after what is now being called the old type; minute investigation he never attempted; he left the microscope to others, beginning his life at the parting of the ways, and interested chiefly with the study of fossil forms, he always remained a morphologist.

NOTES.

THE Paris Academy of Sciences has awarded the Lecomte prize of 50,000 francs to Prof. Ramsay and Lord Rayleigh for their discovery of argon.

THE French Chamber of Deputies has unanimously agreed to refer to the Budget Committee a proposal to contribute to the Pasteur statue. The Committee and the Government will decide on the amount.

IN connection with the visit of the British Association to Liverpool in 1896, meetings of the sub-committees have been held under the presidency of Sir W. B. Forwood and Mr. E. K. Muspratt. The principal result is to make some alterations in the places of meeting of the various sections. It had been arranged that the reception and the central offices should be in St. George's Hall. It has now been arranged that the sections of physics, chemistry, zoology, and physiography shall hold their meetings at University College, that the Town Hall shall be placed at the disposal of the economic section, and that St. George's Hall and the Walker Art Gallery shall be devoted to the remaining sections of geology, engineering, anthropology, botany, &c. It was announced that Prof. J. J. Thomson had accepted the presidency of the mathematics and physics section, while Mr. J. E. Marr will preside over the geologists, and Prof. E. B. Poulton, Hope Professor at Oxford, the section of zoology. The local secretaries hope to be able to publish shortly a complete list of those who have accepted nomination as presidents in the remaining sections.

THE benefactions recently showered upon American educational institutions are bewildering in their multiplicity and munificence. Among the latest reported are several tracts of land purchased near the new site of the University of the City of New York in the annexed district of New York City, and intended for the benefit of that university. Mr. Frederick Baker has paid 35,000 dollars for a lot which he intends to devote to the erection of a hall. Several acres have come into the possession of the Dutch Reformed Church, and on these a church will be

erected, at a cost of 100,000 dollars, for the benefit of the university. Miss Helen Gould, daughter of the late Jay Gould, has purchased several acres on Loring and Oxford Avenues, north-east of the university *campus*, which is supposed to be intended as a site for residences of the professors, as Miss Gould has already shown herself interested in the university by endowing twelve scholarships of 5000 dollars each.

THE eclipse expedition, briefly referred to in our notes last week, left Brooklyn on December 5 for Aleeshi, on the island of Yezo, the northernmost of the Japan group, to observe the total eclipse of August 9, 1896. The schooner-yacht *Coronet*, the largest yacht in the New York Yacht Club, 133 feet long and of 152 tons burden, was generously placed at the disposal of Prof. David P. Todd, of Amherst, by her owners, Mr. D. Willis James and Mr. Arthur C. James. The yacht has already become famous as the winner of 10,000 dollars in a race across the ocean with the yacht *Dauntless*, and she has also already once sailed round Cape Horn, going from New York to San Francisco in 105 days. The same course will be taken now, and the time of the voyage may be shortened. On arrival at San Francisco, she will be joined by Prof. and Mrs. Todd, Mr. Arthur C. James and wife, and a corps of scientific workers, and will then proceed to her destination, after a short stop at Honolulu. The equipment will include about three tons of apparatus, comprising twenty-five or thirty telescopes, both refracting and reflecting, fitted with automatic photographic cameras, which will be set to take 400 or 500 photographs of the corona during the totality of the eclipse. The exposures will be of varying length, from half a second up to several seconds, and will be made with a series of graduated discs, so as to take, in some cases, the entire corona, and in others, outer and fainter portions of it. Almost all the work of observation will be thus photographic, and only a single observer will note appearances through a telescope. Most of the apparatus is already stowed in the yacht. The lenses, however, will be taken overland in the spring, when the party go to embark at San Francisco.

ANOTHER important scientific expedition set out on December 5; for on that day Mr. Frank H. Cushing left Washington for St. Augustine, Florida, where he will be joined by a number of assistants, and the party will sail on a schooner to Pine Island, below Punta Gorda and the southern Florida keys, where a thorough investigation, which is expected to last several months, will be made into the recently discovered mounds built by a remarkable people, who attained a high state of civilisation. Mr. Cushing has already discovered well-preserved remains of the "Shell Age" of prehistoric man. Objects of art made from shell, and shell implements, were found well-preserved, among the most remarkable being a shell pick, still mounted on its original handle of mango wood. The expedition is under the joint auspices of the Ethnographical Bureau of the United States and the Archæological Department of the University of Pennsylvania.

A FURTHER example of the keen interest taken by the German Government in all that concerns the development of trade is reported by the Vienna correspondent of the *Times* as follows: "A newspaper in the Japanese language has recently been published at Yokohama under English auspices. The aim of this journal, for which only a very moderate charge is made, is to familiarise the people of Japan with British merchandise. It appears that Germany has convinced herself of the efficacy of the enterprise, for that Government has lately instructed the Legation and the various Consulates to consider and report upon the methods best suited to ensure the success of a similar undertaking on German lines. It is now stated on good authority that the issue of a German newspaper has been definitely decided upon. It will be edited at the Academy of Oriental Languages in Berlin, and will be printed in Germany and forwarded to Japan for distribution among the inhabitants free of charge." One wonders whether, under similar circumstances, our own Government would have sought the assistance of a learned Society or Academy to carry out its projects.

FROM the same source, we learn that an expedition, fitted out at considerable expense by the Lyons Chamber of Commerce, and entrusted with the mission of thoroughly investigating the trade and commerce of Eastern Asia, has arrived in China. The expedition is exclusively composed of experts, who have undertaken to study the means of developing the trade with the interior, and to open up the wealth of the country to European enterprise. Whatever measure of success may attend their efforts, they will, at all events, traverse districts hitherto wholly unexplored. Finally, it is reported that at the initiative of the Blackburn Chamber of Commerce an English expedition will start shortly to explore the western provinces of Szu-chuan and Yun-nan.

ONE thing after another has cropped up lately to call the attention of the Government and the press to the need for an inquiry into the reason why England is behind Germany and other nations in the industrial applications of science. Mr. J. Powell Williams, who is the Financial Secretary to the War Office, has just had to confess that dried vegetables of various kinds, prepared in a particular manner, and required for the Ashanti Expedition, had to be procured from Germany, as they cannot be obtained in this country. Possibly the Government is under the impression that carrots, potatoes, and turnips cannot be grown in England. For if not, why is not something done to find out how they can be reduced to a dried condition suitable for keeping and transportation? There are dozens of chemists who know the processes by which vegetables can be best prepared for future consumption, and who would be glad to assist in the development of a new British industry.

ON Monday, Lord Herschell gave an address on the work of the Imperial Institute, in reply to some of the criticisms which have been levelled against it. He showed that the collections of economic products from India and the colonies had grown, and had been of some use to merchants and manufacturers; he also mentioned a few investigations that had been carried on under the auspices of the Institute, and described the work of the commercial intelligence department. There is one point, however, upon which we should like to say a word. Lord Herschell remarked that, in accordance with the original scheme, the buildings of the Institute had been applied to the reception of Congresses, such as the International Geographical Congress. This gives the idea that the Council of the Institute granted, without payment, the use of their buildings to the Congress; and if that had been done, we should regard the action as worthy of an Institute which professes to encourage science. But we understand that the International Geographical Committee had to pay a sum of £1100 for the use of the Institute buildings for the Congress, besides several hundreds more in incidental expenses, and that the whole business connected with the hire of the buildings was conducted in a strictly commercial spirit. Lord Herschell omitted this plain statement of fact from his address; but a few transactions of this character are more than sufficient to dispel the belief that the Institute has the promotion of science at heart.

THE Russian correspondent of the *Lancet* has learnt from Prof. Erisman, the general secretary to the Congress, that the date fixed for the next International Medical Congress is the week beginning August 19 and ending August 26 (New Style), 1897. The official announcement will very shortly be sent to the English press. The Emperor has given his Imperial sanction to the Congress, and the Grand Duke Sergi Alexandro-

vitch, the governor of Moscow (and grandson-in-law to Queen Victoria), has granted it his patronage. The nominal president will probably be the Minister of Public Education; the acting president will almost certainly be Prof. Klein, the Dean of the Faculty of Medicine in the University of Moscow. Prof. Erisman, who holds the chair of Hygiene, has, as already stated, been elected general secretary. The meetings of the Congress will be held in the theatres and laboratories of the University Clinique, the so-called *klinitcheski gorodok*, or clinical townlet. Papers and discussions must be in either the French or German language; Russian has been excluded lest the Congress should become national rather than international, and English on the grounds that it is a language little used or understood by other than Englishmen.

ON Monday afternoon, in the Botanical Theatre of University College, London, Prof. Bonney was presented with his portrait by former geological students of the University of Cambridge and of University College, London. A large number of past and present pupils were present, and Mr. J. J. H. Teall occupied the chair as Prof. Bonney's senior pupil. Mr. J. E. Marr referred to the affection and esteem in which Prof. Bonney was held by all his pupils, and Miss Raisin spoke on behalf of the lady students. At the conclusion of her remarks, Prof. W. J. Sollas made the presentation on behalf of the subscribers. The portrait having been unveiled, Prof. Bonney replied. In the course of his remarks he advised those who heard him never, if they could help it, to take things on trust. No doubt books were of great value, but before they trusted them they must know the writers. They must gather facts, and, having done so, take a comprehensive view of them and treat them as inductive. They should not be fascinated by brilliant hypothesis, nor try to write too much; for careless observation and unsound induction were rather a curse than a blessing to science.

DR. J. BATTY TUKE has been elected President of the Royal College of Physicians of Edinburgh.

THE largest battery of dynamite guns in the world was tested recently at San Francisco, and found to work satisfactorily.

WE understand that the Bruce photographic telescope is to be transferred from Harvard University at Cambridge, U.S., to the University station at Arequipa, Peru.

THE Council of the Royal Statistical Society have awarded the Howard medal of 1895 to Mr. John Watson, for his essay on "Reformatory and Industrial Schools."

REUTER reports that Dr. Warth, of the Geological Survey of India, while gold-prospecting in Chota Nagpur, Bengal, struck a reef of remarkable richness. The Indian Government has ordered the erection of stamps for trial crushings.

THE deaths of the following men of science are announced:—Dr. Popoff, Extraordinary Professor of Physiology in the University of Dorpat; Dr. A. de Cerqueira Pinto, formerly Professor of Organic Chemistry in Bahia; Dr. Teichmann, formerly Professor of Anatomy in Cracow.

SURGEON-COLONEL C. ROE, who has been appointed honorary secretary of the Association for the establishment of a Pasteur Institute in India, has made an appeal for funds to ensure the success of the scheme. There is little doubt that the required amount will be collected.

THE two following afternoon lectures will be delivered at the Royal Institution in January, in addition to the arrangements already announced: Dr. A. Donaldson Smith, "To the North of Lake Rudolf and among the Gallas," and Mr. Walter R. Lawrence, C.I.E., on "The Valley of Kashmir."

PROF. W. H. DALL recently returned to Washington from an expedition to examine the coal-fields of Alaska. He found and brought back pieces of fat of a mammoth preserved in ice for ages, being the first discovery of the kind in America. He also discovered a species of bear not previously known to zoologists, but apparently familiar to residents of Alaska, and known there as the ice-bear.

THE Automatic Telephone Company has just been incorporated at Albany, and will construct a new system of telephones, which, as the name implies, are self-acting and independent of any central office. Each subscriber can make and discontinue his own connections by means of an improved device. Tests have already been made, and the system will be at once put in use in New York and Brooklyn.

AN advance copy of Appendix I. 1896, to the *Kew Bulletin* has been sent us. It contains a list of seeds of hardy herbaceous annual and perennial plants and of hardy trees and shrubs which, for the most part, have ripened at Kew during the year 1895. These seeds are not sold to the general public, but are available for exchange with colonial, Indian, and foreign botanic gardens, as well as with regular correspondents of Kew. We hasten to publish this information for the benefit of directors of botanic gardens across the seas. No application, except from remote colonial possessions, can be entertained after the end of March next year.

A TELEGRAM from Captain Roborovsky, dated December 4, announces that the Russian Tibet expedition has finally returned to the Russian dominions, at Zaisan, after having crossed Dzungaria, by two different routes, on their way from the Lyukchun depression. The same telegram announces that the expedition, which has covered nearly 10,700 miles and made a survey of the whole route, and determined the positions of thirty points by astronomical observations, returns heavily laden with natural history collections: 280 specimens of mammals, 1300 of birds, 450 of amphibia and fishes, 30,000 of insects, 25,000 (1300 species) of plants, 300 of seeds, and 300 geological specimens. The meteorological station at Lyukchun has been working for fully two years.

IT is satisfactory to learn that the efforts made by the *Engineer*, to secure the repeal of the existing legal restrictions on the use of mechanical road carriages, are being well supported by many who are taking personal interest in the new vehicle. From a note in the current number of our contemporary, it appears that all the necessary steps have been taken to bring the subject before the notice of the Government; that Mr. Chaplin, as President of the Local Government Board, has expressed himself in strong sympathy with the movement, and that the memorial to him, prepared by the *Engineer*, and signed by leading manufacturing firms and engineers all over the country, has now been placed in his hands. The way for the introduction of a Bill has thus been prepared, and an association has already been formed to support the demand for freedom to use mechanical road carriages equal to that now enjoyed for horse-hauled vehicles.

THE death is announced, in the *Times*, of M. A. P. Kostycher, Director of Agriculture in Russia. M. Kostycher was appointed Professor of Agriculture in 1876, and created the first laboratory in Russia for the study of soils and agricultural products. He held this appointment for seventeen years, in the course of which he made some very interesting researches into the nature and origin of the celebrated "black earth," which is such a source of wealth to the 250,000,000 acres of land in Southern Russia. His six volumes on this subject are regarded as standard works. In 1894 he was appointed assistant to M. Yermolof, who had just been placed at the head of the Agricultural Department. M. Kostycher contributed a very elaborate

chapter to the work on agriculture and forestry, which was published by the Russian Government at the time of the Chicago Exhibition, and was translated into English by Mr. J. M. Crawford, the Consul-General at St. Petersburg.

ACTING upon the report of the Departmental Committee on the Screening of Side Lights of Ships, the Board of Trade have issued the following instructions to their surveyors throughout the country:—The Committee appointed by the Board of Trade under minute of March 18, 1895, to consider the question of the screening of side lights have reported, *inter alia*: (1) That the Order in Council of January 30, 1893, be cancelled. (2) That in the case of oil lamps the forward edge of the screen, or chock on it, should be in a line parallel to the keel with the inside edge of the wick. (3) That in the case of electric lights there should be a similar screening in regard to the inside edge of the filament. (4) That the breadth of the wick of oil lamps, and of the filaments in the case of the electric light, should be not more than two inches, nor less than one inch, measured at right angles to the fore and aft line of the ship. The Board having decided to adopt the above recommendations, the surveyors are informed that the instructions as to the screening of side lights contained in the present issue of "Instructions as to the Survey of Passenger Accommodation, Master's and Crew Spaces," "Lights and Fog-signals," so far as they have either direct or indirect reference to the lights being screened to an angle of convergence of 4° from the outside edge of the wick, are no longer to be put in force, but instead thereof the surveyors are to carry out the directions as to screening contained in above paragraphs, numbered 2, 3, and 4.

THE better protection of wild birds was the object of a deputation that waited upon the Home Secretary on Tuesday. The deputation consisted of members of the eight Councils having an area within the Metropolitan Police district. Mr. Montagu Sharpe said they desired to urge (1) that the close time under Section 8 of the Act of 1880 should be extended; (2) that thirteen new species of birds, in addition to those mentioned in Section 3 of the Act of 1894, should be scheduled; and (3) that the eggs of forty-six species of birds should be scheduled for protection under Section 2 of the Act of 1894. It was desired that the close time for wild birds should be extended to the period between February 1 and August 31. The birds which it was sought to add to the list were the wryneck (cuckoo's mate, or snake-bird), swallow, martin (2), swift, bearded tit (reedling and reed pheasant), kestrel, merlin, hobby, buzzard, honey buzzard, osprey, magpie, and shrike. These birds should be protected not only for their beauty, but for their usefulness in destroying noxious insects, mollusca, and rodents, which were particularly destructive in suburban gardens. The Home Secretary expressed agreement with the proposals of the deputation, and said he would comply with their desire with regard to the scheduling of birds and their eggs.

AN improvement on the simple pendulum for purposes of measurement is described by G. Guglielmo in the *Atti dei Lincei*. The simple pendulum oscillates about its point of suspension in all directions. The compound pendulum rests on a knife-edge, or essentially on two points some distance apart, and therefore oscillates always in the same plane. A bob suspended by two threads will do the same, and will have the additional advantage of simplicity. But for some purposes it is highly desirable to have a body oscillating in the same plane, and parallel to itself. Sgr. Guglielmo has accomplished this by taking two such bifilar pendulums and joining them by a horizontal rod placed in their plane of vibration. This contrivance can be used for a variety of purposes. An electrometer is described in which the rod is replaced by a small cylinder moving inside another, and displaced by any difference of potential between the two. A very useful application of it is the anemometer designed on this plan. A vertical disc is fixed on one end of the rod, and exposed directly to the wind. Wild's anemometer, which consists of a simple plate, the inclination of which alters with the strength of the wind, does not give the horizontal velocity of the wind in a simple manner. The new anemometer always exposes a vertical disc to the wind, and the force is directly given by the deflection of the suspending wires. It should be mentioned that the suspending wires are of iron, joined to the rod and to the supports by short lengths of silk thread to ensure flexibility. Many interesting investigations may be carried out with this apparatus: the influence of the inclination of the disc may be studied, and the indications of Robinson's revolving anemometer may be verified. Oscillations are effectively damped by a wire attached to the rod with a disc attached to its lower end and immersed in water.

WITH the scientific intelligence in the December number of the *American Journal of Science*, we find the following note on underground temperatures at great depths, received by the editors from Prof. A. Agassiz:—"For several years past I have, with the assistance of our engineer, Mr. Preston C. F. West, been making rock temperature observations as we increased the depth at which the mining operations of the Calumet and Hecla Mining Company were carried on. We have now attained at our deepest point a vertical depth of 4712 feet, and have taken temperatures of the rock at 105 feet, at the depth of the level of Lake Superior, 655 feet, at that of the level of the sea, 1257 feet, at that of the deepest part of Lake Superior, 1663 feet, and at four additional stations, each respectively 550, 550, 561, and 1256 feet below the preceding one, the deepest point at which temperatures have been taken being 4580 feet. We propose, when we have reached our final depth, 4900 feet, to take an additional rock temperature, and to then publish in full the details of our observations. In the meantime it may be interesting to give the results as they stand. The highest rock temperature obtained at the depth of 4580 feet was only 79° F.; the rock temperature at the depth of 105 feet was 59° F. Taking that as the depth unaffected by local temperature variations, we have a column of 4475 feet of rock with a difference of temperature of 20° F., or an average increase of 1° F. for 223·7 feet. This is very different from any recorded observations; Lord Kelvin, if I am not mistaken, giving as the increase for 1° F., fifty-one feet, while the observations based on the temperature observations of the St. Gothard tunnel gave an increase of 1° F. for sixty feet. The calculations based upon the latter observations gave an approximate thickness of the crust of the earth, in one case of about twenty miles, the other of twenty-six. Taking our observations, the crust would be over eighty miles, and the thickness of the crust at the critical temperature of water would be over thirty-one miles, instead of about seven, and 8·5 miles as by the other and older ratios. With the ratio observed here, the temperature at a depth of nineteen miles would only be about 470°, a very different temperature from that obtained by the older ratios of over 2000° F. The holes in which we placed slow registering Negretti and Zambra thermometers were drilled, slightly inclined upward, to a depth of 10 feet from the face of the rock, and plugged with wood and clay. In these holes the thermometers were left from one to three months. The average annual temperature of the air is 48° F., the temperature of the air in the bottom of the shaft was 72° F."

THE first part of a cheap edition of "Science for All" has just been published by Messrs. Cassell and Co. So far as we can see, few revisions have been made; hence the work in nowise represents the state of scientific knowledge at the present time.

UNDER the title, "Neue Gedanken zur Vererbungsfrage," the original German text of the article by Dr. Weismann in the *Contemporary Review* for September, has been published by Gustav Fischer, Jena. The article was a reply to one by Mr. Herbert Spencer, in the *Contemporary* of October 1894, and was written at the beginning of this year; but the time taken to translate it into English caused its publication to be delayed until September.

THE Cambridge University Press will publish in a few weeks a comprehensive work on "Ethnology," by Prof. A. H. Keane. The work is divided into two parts, the first dealing with those fundamental problems which affect the human family as a whole, the second discussing those general questions which concern the primary human groups. Evolutionary principles are taken as the basis of construction throughout the work.

THE "Live Stock Journal Almanac" for 1896 has been published by Messrs. Vinton and Co. It contains an abundance of information on all points connected with the breeding and management of live stock, and is plentifully illustrated. Among the articles we notice "Feeding Pastures," by Mr. W. Carruthers, F.R.S.; "Factors in Horse Breeding," by Captain M. H. Hayes; and "Four Feathered Friends," by Mr. A. F. Lydon. The last-named article will do good by showing agriculturists the usefulness of the linnet, chaffinch, goldfinch, and yellow-hammer.

SEVERAL valuable papers on fruit-growing appear in the *Journal* of the Royal Horticultural Society (vol. xix. part 2, November). M. Charles Baltet, President of the French Pomological Congress, describes the principal points connected with the cultivation of fruit in France, and enumerates the principal varieties recommended to fruit-growers, whether amateurs cultivating for home consumption, or farmers for commercial purposes. At a conference held in September, Mr. G. Bunyard described a number of fruits recently brought to the front; Mr. A. H. Pearson gave a paper on pruning fruit-trees; and a prize essay on the commercial aspect of hardy fruit-growing was read. It may be remembered that in the early spring of this year, the Society offered a prize of £10 for the best essay on this subject. Two essays were selected as of equal merit, and the prize, increased by £5, was divided between the authors, Mr. Lewis Castle and Mr. S. T. Wright. Both these essays are printed in full in the *Journal* before us, and we have no doubt that they will give an effective impulse to the cultivation of fruit in this country.

THE additions to the Zoological Society's Gardens during the past week include a Moor Monkey (*Macacus maurus*, ♀) from the East Indies, presented by Mr. Granville Bantock; a Macaque Monkey (*Macacus cynomolgus*, ♂) from India, presented by Mr. Charles Henderson; three American Jabirus (*Mycteria americana*) from the Island of Marajo, North Brazil, presented by Mr. H. A. Astlett; a Spotted Eagle Owl (*Bubo maculosa*) from East Pondoland, South Africa, presented by Mr. R. W. Murray; a Woodcock (*Scolopax rusticula*), British, presented by Mr. Charles Smoothy; two Alligators (*Alligator mississippiensis*) from the Mississippi, presented by Mr. J. Palmer; a Hoary Snake (*Coronella cana*) from South Africa, presented by Mr. J. E. Matcham; a Macaque Monkey (*Macacus cynomolgus*, ♂) from India, a Leopard Tortoise (*Testudo pardalis*) from South Africa, deposited; a Black-necked Stilt Plover (*Himantopus nigricollis*) from South America, nine Long-eared Sun Fish (*Lepornis auritus*), five Rock Bass (*Ambloplites rupestris*), six Catfish (*Amiurus catus*) from North America, a Reeves's Terrapin (*Clemmys reevesi*) from China, two Red-headed Pochards (*Fuligula cerina*), European, purchased.

OUR ASTRONOMICAL COLUMN.

COMETS BROOKS AND PERRINE.—The following ephemeris for Comet Brooks, for Berlin midnight, is by Dr. Berberich (*Ast. Nach.*, 3321):—

	R.A. h. m. s.	Decl. ° ′
Dec. 19	5 8 5	+67 59·0
20	4 50 45	68 27·9
21	34 19	68 47·3
22	18 56	68 58·9
23	4 4 39	69 4·2
24	3 51 30	69 4·5
25	39 29	69 0·9
26	3 28 33	+68 54·2

Comet Perrine is now moving northwards, and is becoming more favourably placed for observation, as shown in the following extract from Dr. Lamp's ephemeris for Berlin midnight (*Ast. Nach.*, 3322):—

	R.A. h. m. s.	Decl. ° ′	Brightness.
Dec. 19	18 31 25	−30 18·4	57·0
20	43 16	29 16·0	
21	52 14	28 6·0	35·3
22	18 59 0	26 55·6	
23	19 4 8	25 47·3	20·4
24	8 6	24 42·6	
25	11 16	23 42·1	12·3
26	19 13 53	−22 45·4	

The brightness on November 18 is taken as unity.

A NEW OBSERVATORY.—We learn from *Science* that the Legislature of Minnesota has granted £2000 for the erection of a student's observatory at the University of Minnesota. The building is already under roof, and is promised for use by January 1, 1896. The equipment will include a 10-inch equatorial of 150 inches focal length. This instrument is to have a triple objective, one combination of which will form the visual telescopic objective, and another the photographic objective. A spectroscope and photograph measuring machine are among the accessories soon to be added. Upon the completion of this working observatory, Prof. Leavenworth will use it to carry on advanced instruction in astronomy.

PHOTOGRAPHY OF MINOR PLANETS.—Dr. Max Wolf, who has taken a prominent part in the detection of new minor planets by the trails which they leave on a photographic plate during a long exposure, describes his method of work in some detail in *Ast. Nach.*, 3319. His photographic telescope consists of a 6-inch portrait lens of 30 inches focal length, and giving a field of about 70 square degrees. In order to distinguish between true planetary trails and defects of the plates, two photographs of each region are taken, the necessary exposures usually not being more than two hours. One of the best methods of detecting differences between two photographs of the same region is to compare a positive with a negative, the films being in contact; the two trails will then be seen in continuation of each other if they are real. Another method of detecting the trails readily is to employ a stereoscope for viewing the two photographs, the change of position bringing out the planet in relief. As might be expected from the instrument employed, measurements of the photographs do not furnish positions with any great degree of accuracy, but they serve as a guide to observers using instruments of greater precision.

It is somewhat remarkable that Dr. Wolf has not telescopically observed any one of the numerous planets which he has discovered by the photographic method.

SHORT PERIOD VARIABILITY.—The recent researches on the spectra of short-period variable stars, more especially of δ Cephei, have no doubt led many to inquire into the possible explanations of the phenomena observed. Among others, Mr. A. W. Roberts, an assiduous observer of this type of variable in the southern hemisphere, has given attention to the subject (*Astrophysical Journal*, November, p. 283). Omitting the Algol variables, which are perhaps sufficiently explained by eclipses, and β Lyræ, which may provisionally be considered as a special case, any satisfactory theory must explain the relative rapidity of the rise to maximum, continuity of variation throughout the period, and the small range of the light changes. In the case of δ Cephei, Belopolsky has shown that the variability is intimately connected with its revolution, the star being apparently

associated with a relatively dark body; and it is perhaps allowable to suppose a similar connection in the case of other variables of the same class. Besides the possibility of eclipses, this orbital movement may operate in two other ways to produce light changes. If the companion be a dark body, there will be phases depending upon its varying reflection of light from the primary, but the changes of magnitude due to this cause will be practically negligible. When the orbit is very eccentric, as in δ Cephei, the temperature of the companion will vary very considerably at different parts of the revolution, and Mr. Roberts seems to regard its consequent changes of brightness as probably the main cause of the variability. It is admitted, however, that the variations of 1·5 or 2 magnitudes, which are occasionally met with, cannot be satisfactorily explained in this way, and it is necessary to suppose an additional variation of the primary itself due to disturbances at periastron. In the variables, like η Aquilæ, which show a secondary minimum, it is only necessary to suppose that an eclipse also takes place. Attention is drawn to two tests of this theory. First, the companion should show itself spectroscopically at the quadrature following periastron; second, telescopic double stars having highly eccentric orbits should exhibit fluctuations of magnitude depending upon the distance between the components. It should be remembered that there is as yet no evidence of luminosity of the companion to δ Cephei, but it may be that the exposures given to the spectrum photographs have been insufficient to depict it.

THE NEW MINERAL GASES.[1]

AS Mr. Crookes has now published (*Chemical News*, August 23, 1895), the wave-lengths of the lines in the spectra of the new mineral gases observed by him in the tubes supplied by Prof. Ramsay, I propose in the present paper to bring together some notes I have made (some of them some time ago) on the same subject.

The researches made at Kensington in connection with the new gases obtained from bröggerite and other minerals has consisted, to a large extent, of comparisons of the lines in their spectra with lines in the spectra of the sun and stars. Preliminary accounts of these comparisons have already been given, and they show that the bright yellow line seen in the gas from bröggerite is by no means the only important one which appears.

Although the general distribution and intensities of the lines in the gases from bröggerite and cleveite sufficiently corresponded with some of the chief "unknown lines" in the solar chromosphere and some of the stars to render identity probable, it was desirable to see how far the conclusion is sustained by detailed investigations of the wave-lengths of the various lines.

The Yellow Line λ 5875·9.—Immediately on receiving from Prof. Ramsay, on March 28, a small bulb of the gas obtained from cleveite, a provisional determination of wave-length was made by Mr. Fowler and myself, in the absence of the sun, by micrometric comparisons with the D lines of sodium, the resulting wave-length being 5876·07 on Rowland's scale. It was at once apparent, therefore, that the gas line was not far removed from the chromospheric D_3, the wave-length of which is given by Rowland as 5875·98.

The bulb being too much blackened by sparking to give sufficient luminosity for further measurements, I set about preparing some of the gas for myself by heating bröggerite *in vacuo*, in the manner I have already described. A new measurement was thus secured on March 30 with a spectroscope having a dense Jena glass prism of 60°; this gave the wave-length 5876·0.

On April 5, I attempted to make a direct comparison with the chromospheric line, but though the lines were shown to be excessively near to each other, the observations were not regarded as final.

Prof. Ramsay having been kind enough to furnish me, on May 1, with a vacuum tube which showed the yellow line very brilliantly, a further comparison with the chromosphere was made on May 4. The observations were made by Mr. Fowler, in the third order spectrum of a grating having 14,438 lines to the inch, and the observing telescope was fitted with a high power micrometer eye-piece; the dispersion was sufficient to easily show the difference of position of the D_3 line on the east and west limbs, due to the sun's rotation. Observations of the chromosphere were therefore confined to the poles.

During the short time that the tube retained its great brilliancy, a faint line, a little less refrangible than the bright yellow one, and making a close double with it, was readily seen; but afterwards a sudden change took place, and the lines almost faded away. While the gas line was brilliant, it was found to be "the least trace more refrangible than D_3, about the thickness of the line itself, which was but narrow" ("Observatory Note Book"). The sudden diminution in the brightness of the lines made subsequent observations less certain, but the instrumental conditions being slightly varied, it was thought that the gas line was probably less refrangible than the D_3 line by about the same amount that the first observation showed it to be more refrangible. Giving the observations equal weight, the gas line would thus appear to be probably coincident with the middle of the chromospheric line, but if extra weight be given to the first observation, made under much more favourable conditions, the gas line would be slightly more refrangible than the middle of the chromosphere line.

Pressure of other work did not permit the continuation of the comparisons. In the meantime, Runge and Paschen announced (NATURE, vol. lii. p. 128) that they also had seen the yellow line of the cleveite gas to be a close double, neither component having exactly the same wave-length as D_3, according to Rowland.

They give the wave-length of the brightest component as 5878·883, and the distance apart of the lines as 0·323.

This independent confirmation of the duplicity of the gas line led me to carefully re-observe the D_3 line in the chromosphere for evidences of doubling. On June 14 observations were made by Mr. Shackleton and myself of the D_3 line in the 3rd and 4th order spectra under favourable conditions; "the line was seen best in the 4th order, on an extension of the chromosphere or prominence on the north-east limb of the sun. The D_3 line was seen very well, having every appearance of being double, with a faint component on the red side, dimming away gradually; the line of demarcation between the components was not well marked, but it was seen better in the prominence than anywhere else on the limb" ("Observatory Note Book").

It became clear, then, that the middle of the chromosphere line, as ordinarily seen, and as taken in the comparison of May 4, does not represent the place of the brightest component of the double line, so that exact coincidence was not to be expected.

Though the observations are not yet quite completed, the circumstance that the line is double in both gas and chromosphere spectrum, in each the less refrangible component being the fainter, taken in conjunction with the direct comparisons which have been made, render it highly probable that one of the gases obtained from cleveite is identical with that which produces the D_3 line in the spectrum of the chromosphere.

Other observers have since succeeded in resolving the chromospheric line. On June 20, Prof. Hale found the line to be clearly double in the spectrum of a prominence, the less refrangible component being the fainter, and the distance apart of the lines being measured as 0·357 tenth-metres (*Ast. Nach.*, 3302).

The doubling was noted with much less distinctness in the spectrum of the chromosphere itself on June 24. Prof. Hale points out that Rowland's value of the wave-length (as well as that of 5875·924, determined by himself on June 19 and 20) does not take account of the fact that the line is a close double.

Dr. Huggins, after some failures, observed the D_3 line to be double on July 10 (*Ast. Nach.*, 3302); he also notes that the less refrangible component was the fainter, and that the distance apart of the lines was about the same as that of the lines in the gas from cleveite, according to Runge and Paschen.

It may be added, that in addition to appearing in the chromosphere, the D_3 line has been observed as a bright line in nebulæ by Dr. Copeland, Prof. Keeler, and others; in β Lyræ and other bright line stars; and as a dark line in such stars as Bellatrix, by Mr. Fowler, Prof. Campbell, and Prof. Keeler. In all these cases it is associated with other lines, which, as I shall show presently, are associated with it in the spectra of the new gases.

The Blue Line, λ 4471·8.—A provisional determination on April 2 of the wave-length of a bright blue line, seen in the spectrum of the gases obtained from a specimen of cleveite,

[1] "On the New Gases obtained from Uraninite. (Sixth Note.)" By J. Norman Lockyer, C.B., F.R.S. Received at the Royal Society, September 10, read November 21.

showed that it approximated very closely to a chromospheric line, the frequency of which is stated as 100 by Young.

This line was also seen very brilliantly in the tube supplied to me by Prof. Ramsay on May 1, and on May 6 it was compared directly with the chromosphere line by Mr. Fowler. The second order grating spectrum was employed. The observations in this region were not so easy as in the case of D_3, but with the dispersion employed, the gas line was found to be coincident with the chromospheric one. In this case also, the chromosphere was observed at the sun's poles, in order to eliminate the effects due to the sun's rotation.

In a former note (*Roy. Soc. Proc.*, vol. lviii. p. 114), I have pointed out that this line does not appear in the spectra of the gases obtained from all minerals which give the yellow line.

Besides appearing in the spectrum of the chromosphere, the line in question is one of the first importance in the spectra of nebulæ, bright line stars, and of the white stars such as Bellatrix and Rigel.

The Infra-red Line, λ 7065·5.—In addition to D_3 and the line at 4471·8, there is a chromospheric line in the infra-red which also has a frequency of 100, according to Young. On May 28, I communicated a note to the Royal Society stating that this line had been observed in the spectrum of the gases obtained from bröggerite and euxenite (*Roy. Soc. Proc.*, vol. lviii. p. 192), solar comparisons having convinced me that the wave-length of the gas line corresponded with that given by Young; and I added, "it follows, therefore, that besides the hydrogen lines, all three chromospheric lines in Young's list which have a frequency of 100 have now been recorded in the spectra of the new gas or gases obtained from minerals by the distillation method."

M. Deslandres, of the Paris Observatory, has also observed the line at 7065 in the gas obtained from cleveite (*Comptes rendus*, June 17, 1895, p. 1331).

Other Lines.—Determinations of the wave-lengths of many other lines in the spectra of the new gases have been made, chiefly with the aid of a Steinheil spectroscope having four prisms, and the results leave little doubt as to the coincidence of several lines with those appearing in the chromosphere, nebulæ, and white stars.

It seems very probable, also, that many lines which have been noted, and for which no origins have yet been traced, belong to gases which have not hitherto been recorded in the chromosphere.

The following table summarises the chief lines which have so far been recorded in the new gases from various minerals, some of which show D_3 while others do not. Only those lines which also appear in the spectrum of the chromosphere, nebulæ, or Orion stars, are given in the first instance. There are other lines which are probably also associated with chromospheric ones, but further investigation of them is considered desirable before they are included in the list.

Wave-length (Rowland).	Wave-length (Angström).	Chromosphere (Young).	Eclipses 1893. Max. intens. = 10.	Orion nebula. Max. intens. = 6.	Bellatrix. Max. intens. = 6.	Crookes' measures.
		Frequency	λR	λR	λR	λR
7065·5	7064·0	100	...	...	...	7065·5
6678·3	6676·9	25	...	...	...	6678·1
6371·6	6370·5	5				
6347·3	6346·2	10				
6141·9	6140·6	15				
6122·43	6121·43	5				
6065·7	6064·5	5				
5991·6	5990·0	15				
5875·9	5874·9	100	5876·0	5876·0	5876·0	5876·0
5429·9	5428·8	8				
5404·1	5403·1	5				
5048·2	5047·8	2	...	...	...	5047·1
5015·8	5015·0	30	5016·0(4)	...	5016·0(1)	5015·9
4922·3	4921·3	30	4922·0(4)	4924(3)	4922·0(2)	4922·6
4713·4	4712 5	2	4713·2(5)	4716(2)	4715·0(3)	4713·4
4471·8	4471·2	100	4471·8(10)	4472(4)	4472·0(6)	4471·5
4389·5	4388·5	1	4390·0(1)	4390(2)	4389·0(5)	4386·3
4026·5	4025·9	*	4026·0(6)	4026(3)	4026·0(6)	4026·1
3964·0	3963·5	—	3963·8	...	3964 0(3)	3964·8
3888·7	3888·0	—	probable†	...	probable	3888·5

* Prof. Young has recently called attention to the fact that although this line was not included in his chromospheric list, he observed and published it in 1883; its frequency is about 15. (NATURE, vol. lii. p. 458.)

† This line is too close to a hydrogen line to enable a definite statement to be made.

The first column of the table gives the wave-lengths of the lines on Rowland's scale, while the second gives the wave-lengths on Ångström's scale; the third gives the frequency of the lines in the chromosphere according to Young. In the fourth column lines photographed with the prismatic camera during the total eclipse of April 16, 1893, are shown; these have been included because in some cases lines which appear to be comparatively unimportant in Young's list were photographed as important lines. The fifth column indicates probable coincidences with lines in the spectrum of the Orion nebula; the accuracy of these wave-lengths is of necessity less than in the case of the chromosphere; with the exception of D_3 they are taken from my paper on the photographic spectrum of the Orion nebula (*Phil. Trans.*, 1895, vol. 186A, p. 76). The sixth column shows probable coincidences with dark lines in the spectrum of Bellatrix, this being taken as an example of the Orion stars (*Phil. Trans.*, 1893, vol. 184A, p. 695), the lines 4922·3 and 5015·8 have been photographed since the date of the paper to which reference is made.

The last column gives the wave-lengths, from Mr. Crookes' table, of the lines observed by both of us.

THE DUKE OF DEVONSHIRE ON EDUCATION.

WITHIN the past few days, the Duke of Devonshire has delivered several orations on educational topics. Two of these addresses appeal especially to those who are interested in technical and scientific education: one was delivered at the annual meeting of the National Association for the Promotion of Technical and Secondary Education, to representatives of technical educational committees of county and borough Councils; and the other was a speech to students at the Birmingham Municipal Technical School. We print extracts from the *Times* reports of both addresses, taking them in the order in which they were delivered. To the conference arranged by the National Association, the Duke of Devonshire said:—

It was originally proposed to hold the conference in July, but that was prevented by the occurrence of the general election. While the general election was responsible for the postponement of the conference, it has also had the effect of converting your president from a private individual, entirely irresponsible, whose saying and doings were entirely his own and committed no one, into a member of the Government, who is responsible both to his colleagues and to Parliament. He happens to be not only a member of the Government, but the person who, with my friend Sir John Gorst, is chiefly charged with the direction of educational questions, and also with the administration of large funds, which are administered by the Science and Art Department as well as the Education Department, and he who, therefore, is concerned with technical and secondary as well as elementary education. This change in the position of your president has occurred at a moment when public attention has been very urgently and earnestly directed both to the question of elementary education, which, in the opinion of some persons, has begun to some extent to trespass upon ground that properly belongs to secondary education, and also by the publication of the report of the Royal Commission on Secondary Education.

We have in the report of the Commission a general review of the history of secondary education in this country, of its present position, and suggestions for its future guidance. Great pains have been taken by the Executive Committee of this Association to give in their journal a trustworthy summary of the work which has thus been undertaken by the County Councils. It will be seen that the plans which have been adopted vary greatly in different counties, and while it is most desirable that the special character of each locality should be considered and a wide scope should be given to experiments, and while not even mistakes and some waste of money inseparable from experimental procedure need be wholly regretted, it has been thought that the time has now come when a more uniform system may be encouraged and adopted. In conclusion, I think I may say that, without attempting to anticipate how soon or how completely it may be in the power of any Government to ask Parliament to consider in a more full and comprehensive manner the organisation of secondary education, including technical instruc-

tion throughout the country, it must be recognised that a great deal of work is at present being done, some of which, we may hope, is of very high practical utility, and all of which is of the highest experimental value. That work is being carried on by local and representative authorities, and it cannot but be an advantage that those who are engaged in it should avail themselves of the opportunity now afforded to them of conference and consultation with each other, and thus finding some of the guidance which, under a more completely and thoroughly organised system, they might possibly look for from some central authority.

On Friday last, the Duke of Devonshire opened the new buildings of the Municipal Technical School at Birmingham, and, in the evening of the same day, he distributed the prizes to students in the school, and delivered an address. The following is a condensed report of his remarks:—

The first question which perhaps may occur to some of you is, "Why am I here at all; why am I selected to address this great meeting?" I have been told before to-day, and I have been told again to-night by the Mayor, that it is as President of the Council and head of the Education Department that I am here. I need scarcely tell you that in the somewhat remarkable arrangements which control appointment to the great political offices it does not follow at all that because a politician is appointed to be the head of the Education Department he should know anything whatever about education. The fact that I hold that office and that others have held that office before me who know as little about education as I do, must convince you that the mere fact of my holding that office does not confer upon me any special qualification for the part I am expected to take to-night, and I am afraid before the conclusion of my address some of you may be reminded of the lines of the poet Pope, who, in speaking of the presence of flies in amber, said:—

> "The things, we know, are neither rich nor rare,
> But wonder how the—something—they got there."

I know no more of science or of art than could be put into the capacity of a couple of nutshells, but every member of Parliament is supposed to know something about education. Unfortunately for my own peace of mind, upon one occasion, some years ago now, I happened to be called upon to distribute prizes at a polytechnic institute in London, where I made some observations upon what I thought was an urgent and growing necessity for a greater amount of attention being paid to the scientific and technical education of our people, which appeared to attract some considerable attention. On the strength, I believe, of that speech, I was asked to assume the post of president of a national association for the promotion of technical and secondary education, and since that unhappy moment my life has been more or less a burden to me, and I have been called upon on more occasions than I care to remember to deliver some observations upon subjects of a scientific and an educational character.

It does not require a scientific or educational expert to show that the work which has been done and is being done and is going to be done here is part of a work which is going on all over the country, and which it is for the working population of this country to take or to leave as they please, but it is a work which it is necessary should be done if we intend to maintain not only the industrial supremacy which we have hitherto enjoyed, but even our existence as a great industrial nation. Even upon such a subject as this I can pretend to speak with no authority. All that I have done upon former occasions and all that I can do now is to refer to what has been said by those who can speak upon such a subject with greater authority than I can. Prof. Huxley was one of those who have taken a lead in this movement for the extension of scientific and technical training. These words of his have been quoted before in this hall, but I shall make no excuse to you for quoting them again. He said:—"We are at present in the swim of one of those vast movements in which, with a population far in excess of that which we can feed, we are saved from a catastrophe through the impossibility of feeding them solely by our possession of a fair share of the markets of the world, and in order that that fair share may be retained it is absolutely necessary that we should be able to produce commodities which we can exchange with food-growing people, and which they will take rather than those of our rivals, on the ground of their greater cheapness or their greater excellence. That is the whole story. Our course, let me say, is not actuated by mere motives of ambition or by mere motives of greed. Those, doubtless, are visible enough on the surface of these great movements, but the movements themselves have far deeper sources. Our sole chance of succeeding in the competition which must constantly become more and more severe is that our people shall not only have the knowledge and the skill which are required, but that they shall have the will and the energy and the honesty without which neither knowledge nor skill can be of any permanent avail."

I should like to add a commentary on those words which was supplied, also, I think, on an occasion similar to this, by Sir Henry Roscoe, who has taken a distinguished and a leading part in this movement. Having quoted those words of Prof. Huxley which I have read, Sir Henry Roscoe said: "This great endeavour to place our population in a position to obtain the industrial supremacy which it has long held and to ensure that supremacy is surely of more fundamental importance than any passing political question of the day. Upon the successful solution of this problem depends our very national existence. Pressed on all sides by the superior scientific education of Germany, by the boundless physical resources and indomitable energy of America, we in this country should have enough to do to hold our own in the coming struggle for existence. Hitherto we have rested content with that pre-eminence which our coal and our iron, our insular position, the energy and capability of our race, have given us; such a state of contentment is at the present time a delusion and a snare. We can afford no longer to live in a false paradise. Our competitors have adopted our industrial methods; they have bought our machinery, and are now not only treading on our heels but are surpassing us. Our competitors have adopted our own discoveries and inventions, and are, as it were, working out our own designs. Watt, Stephenson, Arkwright and Crumpton, Whitworth and Bessemer, have made the world akin in more senses than one. Rapid and cheap transit has revolutionised commerce and industry, and raw materials flow in and finished products flow out, and it is to the nation as well as to the men which furnishes that finished article most cheaply and best that victory comes. This, then, is the meaning of technical and industrial training—to fit our people from top to bottom, from the future leader of industry to the lowest handworker, with the means, so far as education can do so successfully, to carry out his life's work. This is the great task we have set ourselves to accomplish." I ask you whether in your opinion this language is exaggerated. I do not think that any man of business who is present here this evening will deny the increasing strain of the competition to which we are exposed. He may not accept the remedies which we suggest, but he will not deny the existence of a danger which we fear.

No one, I think, can doubt the closeness of the connection in the present day between science and industrial pursuits—scientific discovery on the one hand and mechanical invention on the other. These are the factors of industrial progress in this or in any other country. Scientific discovery has made known to us the new properties and qualities of matter; and mechanical invention, on the other hand, has applied those discoveries to industrial processes. How can we expect that our nation can take full advantage of those discoveries; how can we expect that we can satisfy the wants of the world which expects to be put in instant possession of all the advantages of these successful discoveries, unless we have trained managers and foremen who are competent to take instant advantage of every one of those discoveries in science or mechanical invention and possess the scientific skill to apply them; and how can we obtain these managers and foremen unless we place within the reach of the great masses of our people and of our working men facilities for acquiring that scientific knowledge? I may further ask you, can these managers and foremen themselves expect to make the most of their own abilities without the assistance of workmen whose eye and whose hand and whose intelligence have been properly trained to carry out their instructions?

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

OXFORD.—For many years the annual reports of the University Extension Delegacy have recorded steady progress in the work committed to its supervision. The report just issued shows that, from September 1894 to May 1895, 1544 lectures were delivered in connection with the Delegacy. The

umber of courses organised by Local Committees showed an increase over those of previous years, but the courses given in connection with County Councils showed a decline. This is because the County Councils have appointed lecturers of their own to carry on the work of the Extension lectures; and because fixed colleges or institutes are taking the place of peripatetic teaching. Oxford centres have never shown a preference for courses of lectures on science subjects: in 1894–95, 142 courses were delivered on history, literature, economics, and art, and fifty-seven courses on various branches of science. That the lectures delivered under the auspices of the Delegacy appeal to a large class is shown by the fact that the aggregate of average attendances during the year covered by the report was 20,809.

MR. HENRY A. MIERS, of the Department of Minerals in the British Museum, has been elected Waynflete Professor of Mineralogy, in place of Prof. Story Maskelyne, resigned.

THE following are among recent appointments abroad: Dr. P. Ehrlich to be Professor of Special Pathology and Therapeutics in the Berlin University. Dr. Janny, *privat-docent* in Surgery, at Budapest, to be Professor; Dr. J. Nevinny to be Ordinary Professor of Pharmacology at Innsbruck; Dr. K. A. Bier to be Extraordinary Professor of Surgery at Kiel; Dr. A. Monti to be Professor of General Pathology at Palermo; Dr. Augustin to be Extraordinary Professor of Meteorology in the Bohemian University at Prague.

THE *Times*, in some noteworthy remarks upon the Duke of Devonshire's Birmingham speech, pointed out the importance of technical education, and the necessity for instruction in fundamental principles. "The people perish for lack of knowledge," remarked our contemporary, "but it is primarily general knowledge that they require. Only upon that foundation can technical knowledge be built up with any chance of obtaining its full advantages. . . . Too much stress cannot be laid upon the cardinal importance of equipping our industrial population with the knowledge which at present is far more copiously and systematically provided by other nations than by ourselves. Indeed, we may question whether even among educational reformers full recognition has yet been given to the fact that time and energy are limited quantities. Is it enough to superadd technical education to a stereotyped course of verbal study? Do we not, in that way, not only waste time which might be much better employed, but postpone the acquirement of manual dexterities to too late a period? It is worth serious consideration whether what is wanted for an industrial population at the present day is not an education essentially technical and practical from a very early age, with the verbal training that now passes for education relegated to a secondary place."

THOUGH in recent years there has been a development of facilities for science instruction for boys, and methods of instruction are slowly being improved, the same kind of advances have not been made in girls' schools. This deficiency was discussed at a meeting held at the Hugh Myddelton School last week, when a paper on "Science Teaching for Girls," was read by Mr. Heller, and the essential points of sound teaching of science were dwelt upon. It was pointed out that the teaching of scientific method rather than the teaching of science subjects should be made a valuable educating factor in all schools; that all such teaching must follow the lines of an investigation, must be accurate and quantitative, and must have a logical sequence; that the scholars must be taught to help and think for themselves, and that the teacher should act rather as an exhaust pump than as a force pump, in extracting facts from the child's brain rather than supplying them. Mr. Heller then sketched a syllabus and scheme of work he is carrying out both with classes of teachers and children in East London, where all facts are discovered by experiment, and nothing is given on the *ipse dixit* of the teacher. Referring to the pioneer work the London School Board is carrying out in the training of teachers, the lecturer proposed the following resolution: "That in the opinion of this meeting the time has arrived when the teaching of scientific method should be made an educating influence in girls' schools, and that such teaching must be of an experimental and investigating nature." In the discussion that followed, Dr. Gladstone urged that all knowledge should be gained by scientific methods, and that no special subjects should be taught even in the higher standards of elementary schools, but rather fundamental principles. Dr. Armstrong thought the time was ripe for great changes. In every direction educational authorities were adopting such work as they had heard described. There was no necessity to teach science, but to form character by teaching scientific methods. He advocated the teaching of mental drill and mental discipline, and in conclusion seconded the resolution, which was carried unanimously.

SCIENTIFIC SERIALS.

Wiedemann's Annalen der Physik und Chemie, No. 11.—Emissivity of bodies at high temperatures, and the Auer burner, by Ch. E. St. John. The Auer burner only shows very slight fluorescence and phosphorescence. A thin sheet of oxide on electrically-glowed platinum foil does not assume the temperature of the platinum. The emissivities of glowing bodies are best compared by introducing them into a stove whose walls are at a uniform temperature. The oxides composing the Auer incandescent gas-burner show a high emissive power, which, together with its small mass, large surface, and low conductivity, accounts for its efficiency as an illuminant.—The true surface tension of pure water between 0° and 40° C., by P. Volkmann. This was determined by capillary tubes, and controlled by similar observations upon toluol and benzol. Under a pressure of 750 mm. of moist air, the surface tension of pure water was found to be 7·683 mg. per mm. at 0°, 7·543 at 10°, and 7·236 at 30° C.—Condensation of vapours, by Mathias Cantor. The capillary constants of a surface exert a decided influence upon the dew-point of a vapour in contact with it. The author allowed steam to condense on a thin sheet of petroleum spread on mercury. As soon as the thickness of the layer so deposited is equal to the radius of molecular action, the dew-point and the temperature of saturation become the same. This radius was calculated from the results obtained, and was found to be $6{\cdot}5 \times 10^{-6}$ mm., or slightly less than that found by Reinold and Rücker from soap-bubbles.—Relation between the dielectric constant of a gas and its chemical valency, by Robert Lang. This is an important new law connecting the specific inductive capacity of a gas with its chemical valency. Whatever the nature of the gas, its (sp. ind. capacity − 1) increases directly as the total valency of the atoms constituting its molecules. This difference from unity is called by the author the "electrification number," since it indicates the difference of behaviour in the dielectric ether due to the presence of matter. The electrification numbers of H, O, CO, and CO_2 are very nearly as 1 : 2 : 3 : 4.—Dielectric constants of liquefied gases and the Mossotti-Clausius formula, by F. Linde. These constants of liquefied CO_2, Cl, and N_2O were determined by means of the electric oscillation method. On plotting the calculated and observed values different curves were obtained, and it was evident that the spec. ind. capacity depends upon other conditions besides density.—Circular magnetisation of iron wires, by I. Klemencic. When a current traverses an iron wire, the molecules tend to arrange themselves in circular chains round the axis. This gives rise to strong extra currents at break. The magnetic susceptibilities are different along and round the axis. In soft iron the former exceeds the latter, whereas in Bessemer steel the circular susceptibility is the greater.

IN the number of the *Nuovo Giornale Botanico Italiano* for November, Sigr. M. A. Mirabella has an interesting paper in which he describes the extra-floral nectaries of various species of *Ficus* cultivated in the Botanic Garden at Palermo. They occur as well-marked nectariferous areas on the young branches or under-side of the leaves. In the same number, Sigr. E. Baroni describes several new species of *Lilium* from China.

THE *Bulletini* of the Italian Botanical Society for October and November contain, in addition to papers addressed especially to Italian botanists, several of more general interest. Prof. G. Cuboni describes a successful attempt to obtain in Italy the very rare germination of the seed of the double cocoa-nut of the Seychelles, *Loidoicea Sechellarum*.—Prof. P. Baccarini has found albuminoid crystalloids in the petals of a considerable number of plants belonging to the Leguminosæ, and especially in fugacious flowers; from which he draws the conclusion that they cannot, in these instances, be regarded as a reserve food-material.—Prof. A. Aloi confirms his previous statement that both terrestrial and atmospheric electricity exercise a very beneficial influence on the growth of plants, and predicts that this may be an important element in the agriculture and horticulture of the future.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, November 21.—"On the Calibration of the Capillary Electrometer." By George J. Burch, M.A.

In two previous papers the author has described a method of using the capillary electrometer for measuring rapid variations of E.M.F. A sensitised plate, fixed to a balanced pendulum, is carried with uniform velocity past a vertical slit, so that the movements of the meniscus are recorded in a polar curve, in which time is measured by the angular displacement, and the position of the mercury by the radius vector. In such a curve, the total indicated E.M.F. at any instant is the algebraic sum of the P.D. corresponding to the distance through which the meniscus has moved, and the P.D. corresponding to the velocity with which it is moving. In a good instrument the latter is proportional to the subnormal to the curve at that point. The validity of this method depends on the use of an apparatus of which the time-relations correspond to the formula $r = ae^{-c\theta}$, and in the present communication the author describes a practical method of determining the time-constants of a capillary. The first step is the calibration of the scale-readings. This is effected by fixing a glass millimetre scale to the focussing screen, and measuring the E.M.F.s necessary to produce a permanent excursion from the upper limit of the slit to a series of points 5, 10, 15, &c., millimetres lower. For the calibration of the subnormals two normal excursions are photographed with the capillary in the same position. In one the zero is below the field of view, and the movement is directed upwards, and in the other the zero is raised above the field of view, and the potentiometer wires reversed so as to produce a downward excursion.

The object is to obtain two curves in opposite directions running right across the plates, the exact extent and relative position of the excursions being immaterial. The subnormals to these curves are measured at points 5, 10, 15, &c., millimetres from the upper limit of the slit. The author shows that the algebraic difference between the polar subnormals to corresponding points upon two oppositely directed excursions is constant if the time-relations of the instrument agree with the formula $r = ae^{-c\theta}$. With some capillaries the velocity of the meniscus may be different, for the same acting P.D., at different parts of the tube. In such cases the multiplier which turns subnormal readings into volts is proportional to the algebraic difference of the subnormals for any given position of the meniscus. To find the absolute value of this multiplier, a third photograph is taken in which a normal excursion of known value starts from a zero-point within the field of view. The subnormal to this curve is determined for some one of the selected positions, and the corresponding acting P.D. found by subtracting the electrical value of its distance from the zero-line from the P.D. indicated by the potentiometer. The shape of this curve at its origin shows whether the instrument is dead-beat. If the velocity of the meniscus increases after the excursion has begun, the capillary should be rejected. The entire calibration can be completed in about two and a half hours, and the method is applicable to any dead-beat instrument. The author concludes with a criticism of recent papers by Prof. Einthoven on the same subject.

Physical Society, December 13.—Special General Meeting.—Prof. Reinold, Vice-President, in the chair.—The resolution, with reference to the change in the amount of the life-composition fee, passed at the special general meeting held on November 22 last, was confirmed. The ordinary meeting was then held.—Dr. John Shield read a paper on a mechanical device for performing the temperature corrections of barometers. The form of barometer to which the author has adapted his device is that devised by Dr. Colley; it is intended for general laboratory use, and is capable of being read to within 0·1 mm. The barometer tube can be moved in a vertical direction so that the lower meniscus can be adjusted to the zero of the scale. Attached to the barometer tube is a thermometer with a horizontal stem, passing in front of a scale which is fixed to the vertical scale of the barometer. The graduations of this thermometer scale, with the exception of the one passing through the 0° C. mark on the thermometer, are inclined to the vertical, and are so spaced that the reading opposite the end of the mercury column of the thermometer gives directly the correction to be applied to the observed height of the barometer (B_t) in order to obtain the reduced height (B_0). That is, the reading on the thermometer scale gives the value of $B_t(\beta - \gamma)t$ where β and γ are the co-efficients of expansion of mercury and of the material of which the barometer scale is composed respectively, and t is the temperature. Mr. Boys admired the simple method the author had adopted for plotting the corrections; and said he always felt that the trouble involved in applying small corrections ought if possible to be avoided, or the correction would often be omitted. Mr. Appleyard advised the placing of the bulb of the thermometer within the barometer tube. Dr. Shield in his reply said as the barometer was only intended to read to 0·1 mm., the placing of the thermometer within the tube did not appear necessary.—A paper by Prof. Rücker, on the existence of vertical earth-air electric currents in the United Kingdom was, in the absence of the author, read by Mr. Kay. In a paper read before the British Association at Oxford, Dr. Schmidt stated that he had expanded the components of the earth's magnetic force in series, and had deduced expressions, two of which give the magnetic potential on the surface of the earth in so far as it depends on (1) internal and (2) external forces. The third series represents that part of the magnetic forces which cannot be expressed in terms of a potential, but must be due to electric currents traversing the earth's surface. Dr. Schmidt concluded that such currents amount on the average to about 0·1 ampere per square kilometre. The author has tested this conclusion, drawn from the state of the earth as a whole, by means of an examination of the line integral of the magnetic force round a re-entrant circuit, taken in the United Kingdom. The necessary data have been obtained from the results of the magnetic surveys for the epochs 1886 and 1891, carried out by the author and Dr. Thorpe. Two circuits called the α and β circuits were selected, having their greatest extension north and south, and east and west respectively. The work done by a unit magnetic pole on traversing these circuits was calculated for the epoch 1886 by means of the terrestrial lines found for that date, and also for the epoch 1891 by means (1) of the same lines when due allowance was made for secular change, and (2) of the independent set of lines found by aid of the 1891 survey. The same calculation was made for a third circuit (γ), using instead of the calculated terrestrial lines the true values of the forces and declinations as deduced from the nearest stations. The following table gives the results in amperes per square kilometre.

	α	β	γ
1886 ...	−0·026 ...	−0·004 ...	—
1891 (1) ...	+0·001 ...	−0·005 ...	—
1891 (2) ...	— ...	— ...	−0·008

From these figures the author concludes that there is not in the United Kingdom, at any rate, a vertical current amounting on the average to 0·1 ampere per square kilometre.—Mr. Watson said a few words on the difficulty experienced in determining the line integral in South Wales due to the presence of closed curves.—The Society then adjourned till January 24, 1896.

Zoological Society, December 3.—Sir W. H. Flower, K.C.B., F.R.S., President, in the chair.—The Secretary read a report on the additions that had been made to the Society's menagerie during the months of October and November 1895, and called attention to the acquisition of a specimen of the wild goat of the island of Giura, in the Ægean Sea (*Capra dorcas*).—Mr. Tegetmeier exhibited a specimen of a crab with a supernumerary claw.—A communication was read from Dr. G. Stewardson Brady, F.R.S., containing a supplementary report on the Crustaceans of the group Myodocopa obtained during the *Challenger* expedition, to which were added notes on other new or imperfectly known species of this group.—Mr. F. E. Beddard, F.R.S., read papers on some points in the anatomy of *Pipa americana* and on the diaphragm and the muscular anatomy of *Xenopus*. The author added remarks on the affinities of these two anomalous Batrachians, which he considered to have been correctly placed together in the system.—Mr. W. Bateson, F.R.S., gave an acount of the colour-variations of a variable beetle of the family Chrysomelidæ (*Gonioctena variabilis*) statistically examined. It was shown that the individuals are chiefly either red spotted with black, or else greenish grey striped with black. All intermediates occurred, but were less common than the type-varieties. These facts illustrated the phenomenon of organic stability.—A communication from Mr. R. Lydekker, F.R.S., contained remarks on the affinities of the so-called extinct Giant Dormouse of Malta. The author stated that this extinct rodent did not belong

to the Myoxidæ, but rather to the Sciuridæ, unless it were necessary to assign it to a family apart. He proposed for its reception the new generic term *Leithia*.—A communication was read from Mr. W. E. Jennings Bramley, giving an account of the mode of capturing Loder's Gazelle (*Gazella loderi*), used by the Arabs of the Western Desert of Egypt.—Mr. G. A. Boulenger gave descriptions of a new snake (*Typlops nigricauda*) and of a new frog (*Chiroleptes dahlii*) from Northern Australia.—A second paper by Mr. Boulenger contained an account of the type-specimen of *Boulengerina stormsi*—an Elapoid Snake from Lake Tanganyka, recently described by M. Dollo.

Geological Society, December 4.—Dr. Henry Woodward, F.R.S., President, in the chair.—On the alteration of certain basic eruptive rocks from Brent Tor, Devon, by Frank Rutley. The author gave a detailed account of the microscopic characters of sections of rocks from Brent Tor, and discussed the history of the rocks, comparing them with Tertiary basic glass, and with the Devonian rocks of Cant Hill, which he described previously. He brought forward evidence in favour of the view that the original alteration of both the Brent Tor and Cant Hill rocks was palagonitic, and that while in the Brent Tor rocks the subsequent alteration of the palagonite into felsitic matter, magnetite, secondary felspar, epidote, and probably kaolin, and some serpentine and chlorite was complete, it was only partial in the case of the Cant Hill rocks.—The Mollusca of the Chalk Rock (part i.), by Henry Woods In the introductory part of the paper, the author gave an account of the characters, distribution, and literature of the Chalk Rock. The main part of the paper was devoted to the consideration of the cephalopoda, gasteropoda, and scaphopoda. Some new species were described, and the synonymy and distribution of the others treated in detail, figures and descriptions being given of the forms not previously well known. The account of the lamellibranchs and the general conclusions were reserved for part ii.

PARIS.

Academy of Sciences, December 9.—M. Marey in the chair.—M. Marey gave an account of his visit to the Royal Society, London, in his official capacity as President, on the occasion of the celebration of the anniversary of the foundation of that Society.—Analysis of aluminium and its alloys, by M. Henri Moissan.—Morphological study of the lymphatic capillaries of Mammifers, by M. L. Ranvier.—Valuation of meals as regards their value for baking purposes; estimation of the waste due to the husk and germ which may lower the quality of the bread, by M. Aimé Girard —On the variations of the ratio of the specific heats of fluids—carbonic acid, by M. E. H. Amagat.—On the analysis of soil by plants, by M. G. Lechartier.—Resistance of straight beams fixed on elastic supports, by M. Paul Toulon.—Application of integral invariants to the reduction to the canonic type of any system of differential equations, by M. G. Kœnigs.—On the number of classes of quadratic forms of negative determinant, by M. Matyas Lerch.—On the varieties of unicursals of three dimensions, by M. Autonne.—On orthogonal systems, by M. E. Goursat.—On the photography of stationary luminous waves, by M. Izarn.—Absorption of nitrogen by lithium in the cold, by M. H. Deslandres.—On a possible process for the separation of argon and atmospheric nitrogen, by M Claudius Limb.—Action of alcohol on mercurous iodide, by M. Maurice François. Boiling alcohol decomposes mercurous iodide. The decomposition ceases when 100 grams of liquid contain, in round numbers, 0·220 grams of mercuric iodide in solution. This action is reversible, and the inverse action stops at the same limit. The quantitative separation of mercurous and mercuric iodides by alcohol is not exact.—New synthesis of parafuchsine and its mono-, di-, tri-, and tetra-alkoyl derivatives, by M. Maurice Prud'homme.—On a mode of decomposition of some organic substances with amide or imide functions, by M. Œchsner de Coninck.—On the approximate limits of the accuracy of the estimation of marsh-gas by means of the platinum- or palladium-thread grisoumeter, by M. J. Coquillion.—On the distribution of boric acid in nature, by M. H. Jay. Boric acid is very widely spread, is absorbed by plants but rejected by the animal economy.—Solubility and activity of soluble ferments in alcoholic liquids, by M. A. Dastre.—Experiments on the "blanc de champignon" obtained by germination in a sterilised medium, by MM. J. Costantin and L. Matruchot.—On the mechanism of muscular contraction, by M. A. Imbert.—Experimental researches on the silent electric discharge, by M. Henry Bordier.—On the constitution and structure of the osseous spine of the dorsal fin in some malacopterygian fishes, by M. Léon Vaillant.—On the metamorphism of the Cambrian of the "Montagne Noire," by M. J. Bergeron.—On the measurement of the intensity of perfumes applied to biological researches, by M. Eugène Mesnard.—Fixation of tannic acid and gallic acid by silk, by M. Léo Vignon.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

BOOKS.—Euclid's Elements of Geometry: H. M. Taylor (Cambridge University Press).—La Topographie: Prof. P. Moëssard (Paris, Gauthier-Villars).—Beiträge zur Geophysik, 2 Band, 2-4 Heft (Stuttgart, Koch).—Rambles and Studies in Bosnia, Herzegovina, and Dalmatia: Dr. R. Munro (Blackwood).—Lehrbuch der Botanik für Hochschulen, Strasburger, Noll, Schenck and Schimper, Zweite Umgearbeitete Auflage (Jena, Fischer).—Handbuch der Poläarktischen Gross-Schmetterlinge für Forscher und Sammler: Dr. M. Standfuss (Jena, Fischer).—Peru: E. W. Middendorf, 3 Band (Berlin, Oppenheim).—Public Health in European Capitals: Dr. T. M. Legge (Sonnenschein).—Problems in the Use and Adjustment of Engineering Instruments: W. L. Webb (Chapman and Ha l).—Rope Driving: Prof. J. J. Flather (Chapman and Hall).—Elementary Principles of Mechanics: Prof. A J. Du Bois. Vol. 3. Kinetics (Chapman and Hall).—A Treatise on Hydraulics: Prof. H. T. Bovey (Chapman and Hall).—Missouri Geological Survey, Vols. 4 to 7 (Jefferson City).—Smithsonian Institution, Report of the U.S. National Museum, 1893 (Washington).—Geological and Natural History Survey of Minnesota Reports, 1893-4 (Minneapolis).—U.S. Department of Agriculture, Report of the Chief of the Weather Bureau, 1893 (Washington).—Les Cavernes et Leurs Habitants: Prof. J. Fraipont (Paris, Baillière).—Mammals of Land and Sea: Mrs. A. Bell (Philip).—Handbuch der Mineral Chemie: Dr. C. F. Rammelsberg, Zweite Auflage, 1 and 2 Theil, and Ergänzungsheft zur Zweiten Auflage (Leipzig, Engelmann).—Object Lessons for Infants: V. T. Murché, Vol. 1 (Macmillan).—Practical Plane and Solid Geometry: J. Harrison and G. A. Baxandall (Macmillan).—Elementary Mensuration: F. H. Stevens (Macmillan).—British Guiana and its Resources (Philip).—The Physiology of the Carbohydrates: Dr. F. W. Pavy (Churchill).

PAMPHLETS.—Ueber einige Probleme der Physiologie der Fortpflanzung: Prof. G. Klebs (Jena, Fischer).—Grundzüge der Marinen Tiergeographie: Dr. A. E. Ortmann (Jena, Fischer).—Reconnaissance of the Gold Fields of the Southern Appalachians: G. F. Becker (Washington).—Health Notes for the Seaside: A. C. Dutt (Whitby).—Common Sense in Chess: E. Lasker (Bellairs).

SERIALS.—Journal of the Franklin Institute, December (Philadelphia).—American Journal of Science, December (New Haven).—Engineering Magazine, December (Tucker).—Contributions from the U.S. National Herbarium, Vol. 3, No. 4 (Washington).—Proceedings of the Calcutta Academy of Sciences, 2nd series, Vol. v. Part 1 (San Francisco).

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